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Quarterly Progress Report

Division 6

15 June 1958

Digital Computer (U)

ASTIA 302443
AFCRC-TN-58-1013

Lincoln Laboratory
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

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DEPARTMENT OF THE AIR FORCE
HEADQUARTERS ELECTRONIC SYSTEMS DIVISION (AFSC)
HANSCOM AIR FORCE BASE, MASSACHUSETTS 01731

#1719

REPLY TO ATTN OF: ALFL (Lincoln Laboratory) 17 Dec 84

SUBJECT: Declassification of Lincoln Laboratory Documents

TO: Mr. M. Wesley/A-109
Security Office
Lincoln Laboratory

1. Reference your letter of 17 Nov 1983 requesting declaassification and public release of MIT Lincoln Laboratory Quarterly Progress Reports issued between June 1952 and December 1958 (see atch 1).

The first major hurdle of this process has been cleared. Attachment 2 authorizes the declassification of the following documents:

"Quarterly Progress Reports - Division 6 - Digital Computer"

15 Jun 1954 (C)-(LL # 1, C315172C)
15 Sep 1954 (C) (LL # 1, C315189C)
15 Sep 1956 (C) (LL # 1, C315208C)
15 Mar 1957 (C) (LL # 1, C315206C)
15 Jun 1957 (C) (LL # 1, C315253C)
15 Sep 1957 (C) (LL # 1, C315254C)
15 Dec 1957 (C) (LL # 1, C315255C)
15 Mar 1958 (C) (LL # 1, C315256C)
15 Jun 1958 (C) (LL # 1, C315257C)
15 Sep 1958 (C) (LL # 1, C315258C)
15 Dec 1958 (C) (LL # 1, C315313C)

The next major hurdle is obtaining public release. This will be done through ESD Public Affairs (Mr. John O'Brien).

ORIGINAL SIGNED BY

THOMAS J. ALPERT, Major, USAF
Chief, ESD Lincoln Laboratory Project Ofc

2 Atch
1. Lincoln Laboratory Ltr, 17 Nov 1983
2. NORAD Ltr, 26 Nov 84

Cy to: D. Murphy/B-107 w/atch
W. Hill/L-339 w/atch

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HEADQUARTERS
NORTH AMERICAN AEROSPACE DEFENSE COMMAND
PETERSON AIR FORCE BASE, COLORADO 80914-5001

REPLY TO ATTN OF J30S

26 NOV 1984

SUBJECT Classification Review "Quarterly Progress Reports"

TO ALFL (Lincoln Laboratory)

1. In response to ALFL letter, 28 Nov 83, the (11) confidential documents titled "Quarterly Progress Reports - Division 6 - Digital Computer" and dated 15 Jun 1954 through 15 Dec 1958 have been reviewed. Recommend the documents be declassified in whole since the sage system computer no longer exists and information contained in the documents no longer has an effect on national security.

2. To officially declassify these, documents, the 416L Security Classification Guide OPR, which is at HQ Sacramento Air Logistics Center, McClellan AFB, CA (MMCM), must be contacted with the recommendation to declassify.

JOHN E. MOORS, LCOL, CF
Ch, At Sensors Division

Memo for Record 14 Dec 84

Talked, by phone, with Ed Smalden, Sacramento ALC/MMCM, McClellan AFB, CA. Based on the recommendation in this letter he considers these documents declassified.

THOMAS J. ALPERT, MAJOR, USAF
CHIEF, ESD LINCOLN LABORATORY PROJECT OFC

Atch 2

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42-677

This document comprises
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Quarterly Progress Report

Division 6

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The Air Force Declassification Office
concurs in the marked classification.
Date: 5/14 Reviewer: 137

15 June 1958

Digital Computer (U)

Issued 17 November 1958

ASTIA 302443
AFCRC-TN-58-1013

Lincoln Laboratory

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Lexington, Massachusetts

H. G. WEISS
DEC 15 1958

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DIVISION 6 SUMMARY

In the Experimental SAGE Sector (ESS), 29 system tests were conducted including 14 shakedown tests using Model 1 of the direction center active (DCA) program. The "Design and Implementation Status of the 1960 SAGE System" was published. Assistance was given to ADC in the preparation of the employment plan for the IM-99B. Operational specifications were written for an experimental airborne long range radar input (ALRI) system. Definite improvement in tracking ability was confirmed as a result of minor changes in the logic of the tracking program. Operational and mathematical specifications for an experimental system to evaluate some aspects of the possible integration of SAGE and civilian air traffic control were drafted. A prototype thin film computer memory was built. The assembly of the TX-2 experimental computer neared completion.

Twenty-nine system tests were conducted in ESS: 14 were for shakedown, 6 were for evaluation, and 9 for operator training. In shakedown, emphasis was placed on verifying modifications in the intercept direction, automatic tracking, and crosstell functions. The tracking ability of the ESS DCA program was analyzed in several studies: minor logic changes and the use of the dual tracking feature were both observed to improve its ability to track maneuvering targets.

The construction of an experimental ALRI digital data processor began and operational specifications for the system were written; ALRI will extend the SAGE air surveillance and weapons control to some 300 miles seaward from the coast. A SAGE/BOMARC IM-99B system description includes ALRI to extend SAGE low-altitude offshore air surveillance to take advantage of the low-altitude capability of that missile. The system description also includes improved ECM capability; for example, the target seeker in the missile is ECM resistant, sees farther, and has search-while-go capability. A description of new design features planned for the 1960 SAGE computer program includes: increased track capacity, control of the IM-99A, control of century series interceptors, AA operation with Missile Masters, and Mode II capability.

Detailed operational and mathematical specifications for the CAA high altitude remote monitor (CHARM) system were drafted. CHARM will investigate the feasibility of cooperative air surveillance by SAGE and civilian air traffic control: SAGE radar data, combined with flight plan information furnished by the Boston Air Route Traffic Control Center, will be processed by the Whirlwind I computer, correlated by track monitors, and sent to the Control Center for display.

R.R. Everett
Division Head

J.F. Jacobs
Associate Division Head

10 October 1958

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TECHNICAL INFORMATION RELEASES

1 March 1958 – 31 May 1958

TIR No.	Release Date	Material Released
1-240	7 March 1958	6M-5473, "System Office Recommendation: Normal Area Assignment Control, AN/FSQ-7, AN/FSQ-7 (XD-1), and AN/FSQ-8 (SOER #210)," dated 4 February 1958.
1-241	7 March 1958	6M-5469, "System Office Recommendation: Chairs for SAGE Operators," dated 5 February 1958.
1-242	10 March 1958	6M-5472, "System Office Recommendation: Combat Center Variable Display Equipment (SOER #207)."
1-243	18 March 1958	6M-5233, "System Office Recommendation: AN/FSQ-7 Crosstell Input System."
1-244	28 March 1958	2M-0885, R1, "VHF Transmitter BC-640," dated 27 March 1958.
1-245	8 April 1958	2M-0156, "VHF Receiver BC-639," dated 3 March 1958.
1-246	24 April 1958	2M-0174, "Geographical Coordinates for SAGE Radars," dated 2 April 1958.
1-247	8 May 1958	6M-5596 and S1, "020 Computer Entry Punch."

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SYSTEM DESIGN

GROUP 61

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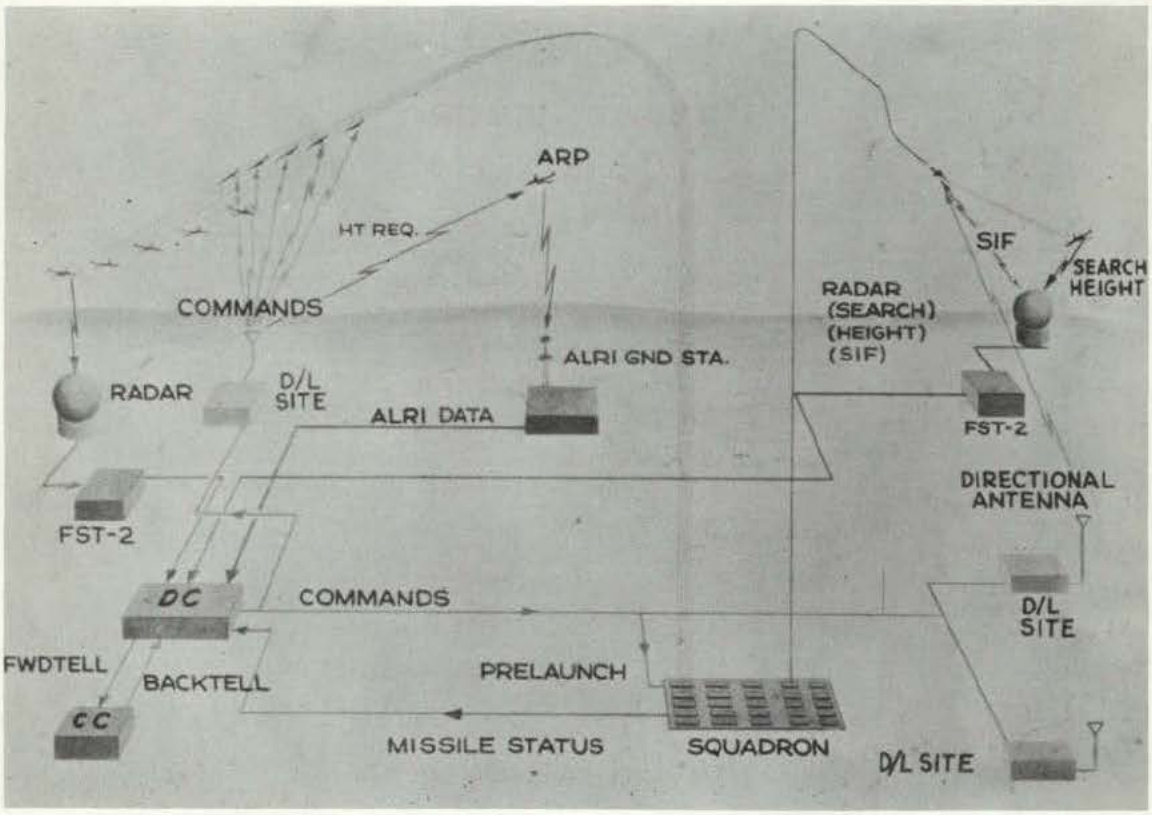

Fig. 61-1.* SAGE/BOMARC system.

*Figures 61-1 through 61-5 are reproduced from "Joint Presentation – IM-99B/SAGE Employment Conference, April 28 – May 2, 1958, Seattle, Washington, D 5-2952."

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I. SYSTEM DESIGN
GROUP 61

A. SUMMARY

Group 61 participated in a working group which wrote a SAGE/IM-99B system description that was incorporated in the ADC employment plan for the missile. The employment plan calls for: the use of airborne long range radar input (ALRI) aircraft which will make possible SAGE control of the IM-99B at high and low altitudes to the limit of its effective range off shore, and strobe triangulation techniques in an ECM environment.

Two IM-99A simulations were checked out, and a series of tests was begun to select best parameters for missile tracking and guidance.

A study of SAGE tracking effectiveness confirmed the advisability of changes to the program recommended last quarter. The modified program performed satisfactorily for aircraft speeds up to 900 knots, maneuvers up to 120 degrees, and horizontal accelerations to 3 g's.

Planning for the integration of time-division data link (TDDL) continued and program changes necessary to provide TDDL capability in ESS were documented.

B. BOMARC

1. IM-99B Employment Plan

The SAGE-BOMARC working group,* formed last quarter, produced a SAGE/IM-99B system description which became Lincoln Laboratory's contribution to the ADC employment conference in Seattle, 28 April to 2 May. The working group also participated in the writing of the operational employment plan, dated 2 May.

The SAGE-BOMARC system is shown schematically in Fig. 61-1. SAGE surveillance data on the target aircraft is provided by the search and height radars, and the missile is tracked with Mark X SIF. The air situation (and other information, such as weapon status) is processed at the SAGE direction center and presented to the weapons directors. Guidance commands are calculated, automatically transmitted by wire to data link transmitter sites, and radiated from a directional antenna to the weapon. Surveillance data on hostile aircraft is automatically forwarded to the SAGE combat center where a weapon allocation and assignment capability is maintained.

a. ALRI

By the use of ALRI aircraft, SAGE air surveillance can be extended further out from the coast at low altitudes (Figs. 61-2, 3). ALRI aircraft fly within direct line-of-sight of SAGE radars and transmit data back to shore receiving stations. The data is quantized and digitalized in the aircraft before transmission, much like data from ground based SAGE radar sites.†

b. Communications

Time-division data link messages will be transmitted to the missile on UHF frequencies from directional or omni antennas (Figs. 61-4, 5). Command messages are assembled in the

*Consisting of representatives from Groups 21, 25, 42, 45, 61, 62, 67, and 68, Boeing Airplane Co., ADSMO, 4620th ADW, and SDC.

†See ALRI system description in Sec. VII, B of this report.

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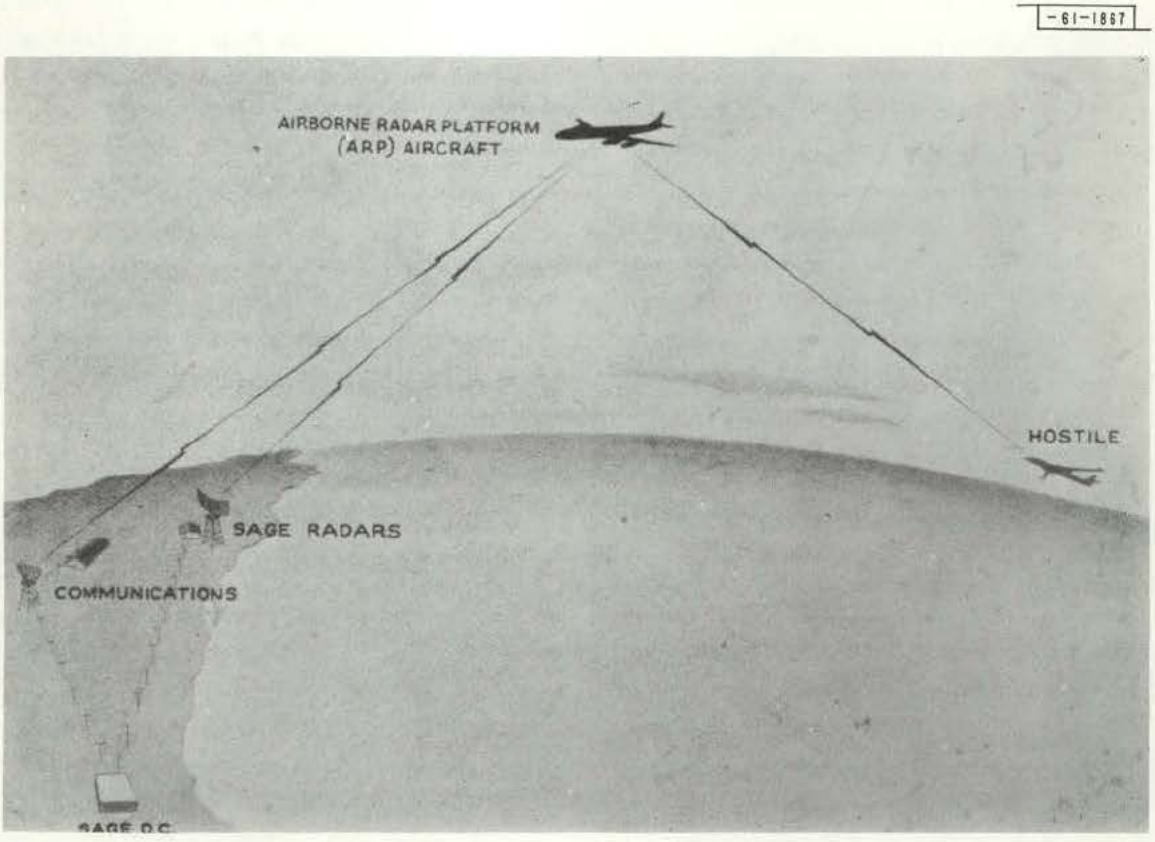

Fig. 61-2. ALRI operational concept.

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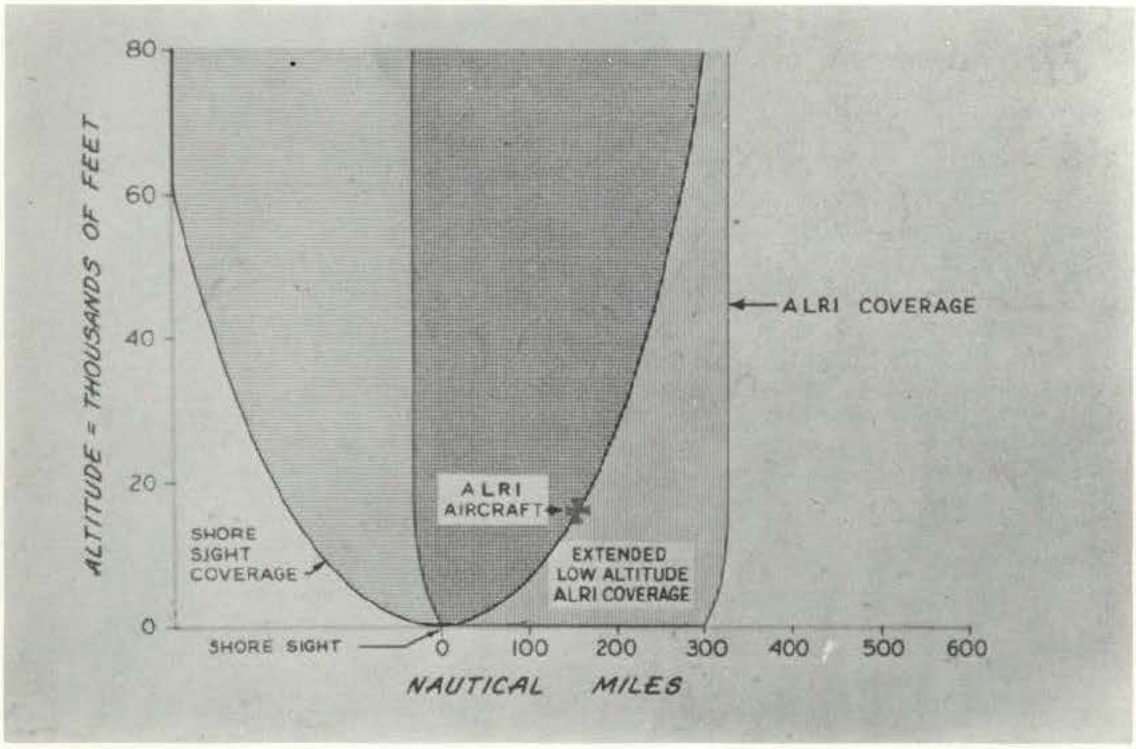

Fig. 61-3. Extension of radar coverage with ALRI.

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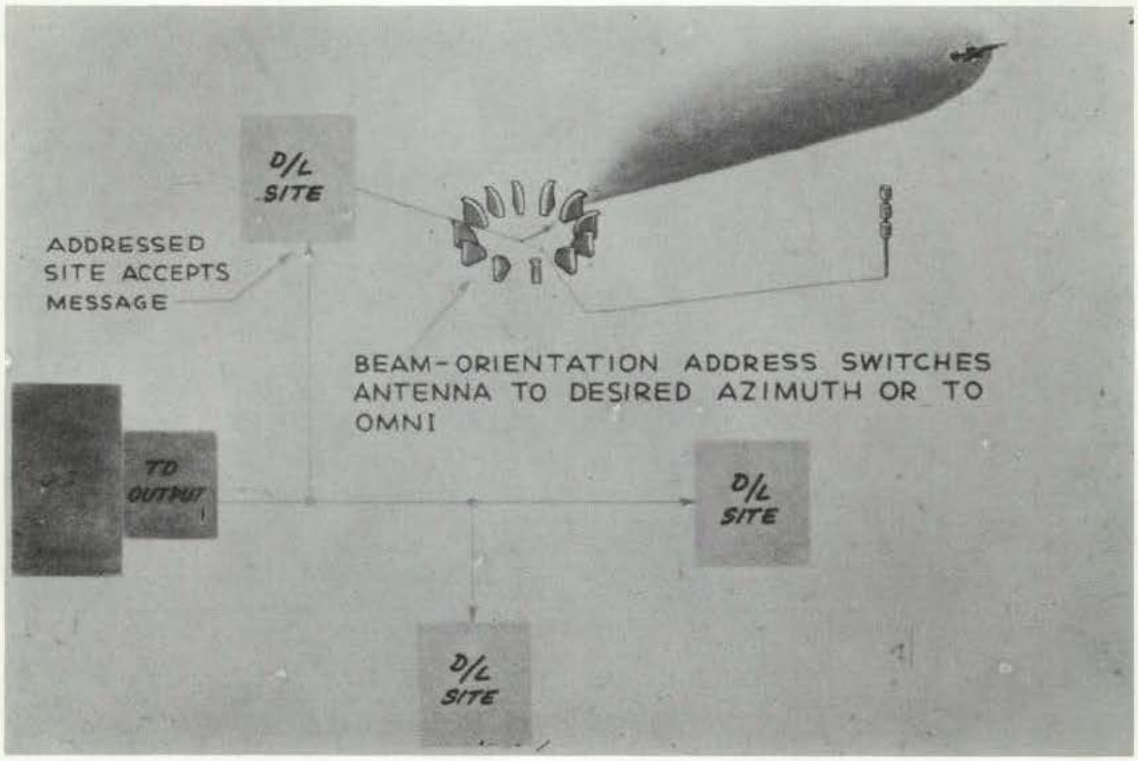

Fig. 61-4. Time-division data link: site addressing and beam orientation.

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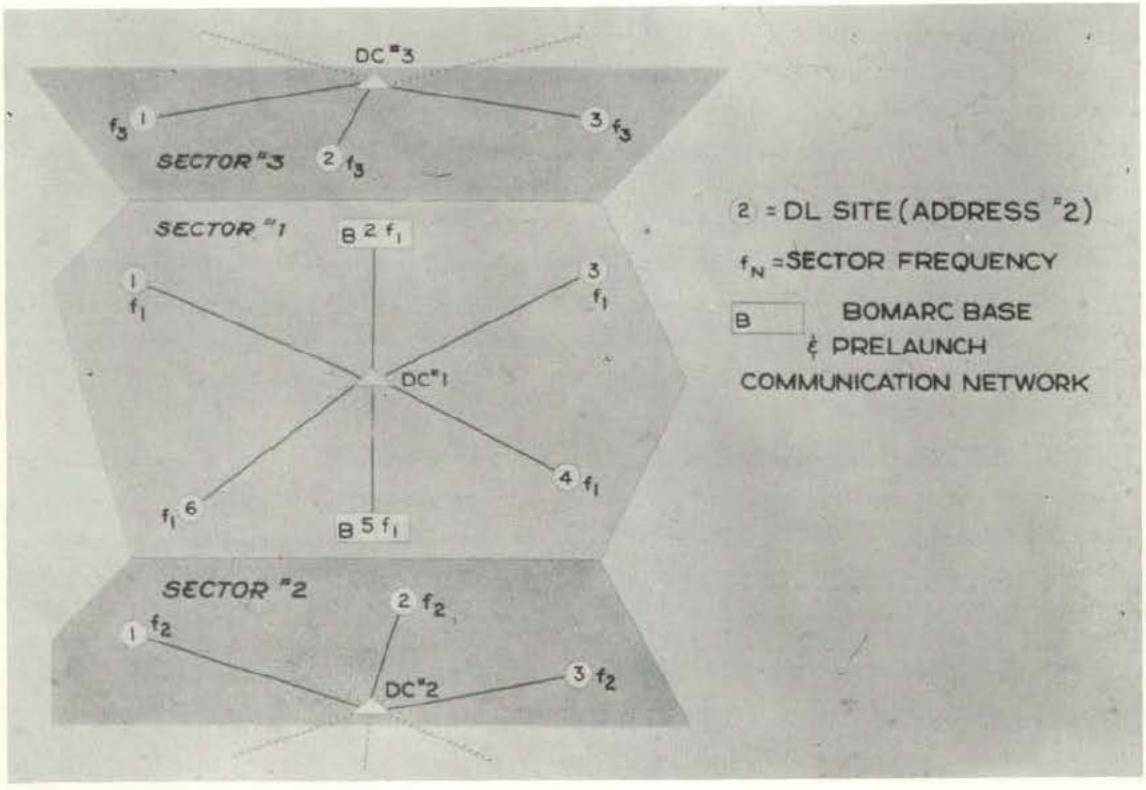

Fig. 61-5. SAGE/TDDL netting (Mode I).

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central computer and fed by the TD output section to the net of ground-to-air transmitters. Each message is addressed to a particular transmitter. The address is decoded at each site, and only the addressed site acts upon the message. Additional address information switches the transmitter to the particular antenna element corresponding to the desired beam azimuth. On the basis of missile track data, the computer thus chooses a site and aims the command transmission at the missile from that site.

c. ECM Capability

Under ECM conditions, the tracking and guidance functions of the system will be aided by strobe triangulation and "deghosting" techniques. The former consists of calculating the approximate position of the jamming aircraft by triangulating the jamming strobes as seen by two or more radars. In the latter technique, the real positions of two or more jammers are differentiated from their several apparent positions as seen by the radars. Deghosting will be performed manually at the direction center, while the intersections determined by triangulation will be tracked automatically. The IM-99B will also have increased capability in the presence of ECM directed at the missile: among these is an ECM-resistant target seeker which will home on the jammer, and the ability to store, before launching, all commands necessary to reach the predicted intercept point.

d. Direction Center Requirements

Some changes to existing equipment and some additional equipment will be required to carry out the employment plan. These include an ALRI input channel, a two-way voice radio channel for ALRI communications, a data link output to the ALRI aircraft, a backtell input channel (from the combat center), and new displays and display consoles.

2. IM-99A Simulation Studies

Two simulations were checked out and used in preliminary tests: SNORT (SAGE non-real-time) and Bobcat, a smaller Canadian simulation. An extensive series of tests* is planned for both programs to investigate various parameters in SAGE/IM-99A tracking and guidance. The proper choice of the threshold function for the guidance program is the largest outstanding problem. The tests will also help determine the effects of target maneuvers, speed smoothing, variations in subframe length, and errors in wind information.

Late in the quarter, production runs with Bobcat were started in order to investigate IM-99A guidance computations, thresholds, and computation rates for both maneuvering and non-maneuvering targets. An early observation, to be confirmed as tests continue, is that target maneuver relative to the completion of midcourse missile flight is far more critical in determining intercept success than guidance thresholds.

C. SAGE TRACKING STUDY

The study of SAGE tracking effectiveness reported in December† has continued in order to evaluate program changes recommended earlier in the study and carried out last quarter. A

*See 6M-5568, "Test Planning for SNORT and Bobcat," by D.W. Ladd and R. Harvey, 27 February 1958.

†Quarterly Progress Report, Division 6, Lincoln Laboratory, M.I.T. (15 December 1957) Sec. I, D, 2.

Canadian simulation named Cairo was used to measure tracking errors for straight-line and weaving targets in areas of single and double radar coverage. The changes included (1) elimination of the "area check" for large search area data when tracking merit is good; (2) smoothing in track coordinates with large search area data regardless of tracking merit; and (3) doubling of the smoothing constants in the large search area.

The recommended program changes have resulted in a substantial improvement in the program's ability to track maneuvering targets. The program performed satisfactorily in all of the target situations investigated, including speeds up to 900 knots, maneuvers up to 120 degrees, and horizontal accelerations to 3 g's. This level of performance assumes double radar coverage and data conditions that are representative of what may be expected in a realistic environment in the absence of ECM and excluding the effects of proximate tracks and radar clutter. Orientation error was assumed to be 0.1 degree, standard deviation of range and azimuth errors 0.25 mile and 0.25 degree, respectively, blip-scan ratio 0.7, and 80 random noise returns per radar scan.

The study confirmed findings reported earlier; namely, that double radar coverage results in better tracking performance than single coverage, tracking accuracy deteriorates rapidly when mean azimuth errors exceed 0.1 degree, and tracking performance falls off sharply for both single and double radar coverage when the standard deviation of the radar azimuth errors exceeds 0.25 degree and when the blip-scan ratio is below 0.7. Under the assumptions mentioned above, tracking accuracy for 500-knot maneuvering targets was as follows:

	Single Radar Coverage	Double Radar Coverage
Position Error (mean of magnitude) – nautical miles	0.63	0.45
Speed Error (mean of magnitude) – knots	26	14
Heading Error (mean of magnitude) – degrees	5	4

These errors decrease with increasing target speed and they are not sensitive to changes in random noise or blip-scan ratio. Maneuvering performance falls off sharply for frame times in excess of 18 seconds but does not vary significantly for frame times between 12 and 18 seconds. For an 80-degree maneuver performed by a 500-knot target with a horizontal acceleration of 0.6 g's under the radar environment described, the error transients subside within about 3.5 minutes after the end of the maneuver, for both single and double radar coverage.

D. TIME-DIVISION DATA LINK

In cooperation with the System Office and other groups, Group 61 continued with certain phases of planning for the implementation of time-division data link (TDDL) in SAGE and ESS. Necessary modifications to the DCA program to provide TDDL capability in ESS were documented; message standards and compatibility problems were discussed with representatives of the Army and Navy; and a description of what the pilot sees as a result of data link messages was begun. In a Data Link Coordinating Committee meeting in May, SDC affirmed its capability to produce and install in the field a DCA program model with TDDL capability by mid-1960, however no formal commitment to this effect has been made. TDDL equipment is now being installed in ESS by IBM, BTL, and RCA, and testing of the subsystem is expected to begin next quarter.

ESS INSTALLATION

GROUP 62

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II. ESS INSTALLATION
GROUP 62

A. SUMMARY

Definite plans were laid for building a prototype airborne long range radar input (ALRI) system, and the assignment of personnel and procurement of equipment began. ALRI would extend SAGE high- and low-altitude radar coverage, and permit SAGE air surveillance, identification, and weapons control seaward to about 300 miles from the coast. The group continued development of diagnostic computer programs (called UDAS) to operate with the direction center active (DCA) program in the Experimental SAGE Sector (ESS): six new programs were planned which will aid in subsystem maintenance. Additional indicators and alarms were designed for the maintenance coordinator's console in AN/FSQ-7 (XD-1) to further centralize and improve this function.

B. ALRI: AIRBORNE LONG RANGE RADAR INPUT

The preliminary investigation of ALRI made last quarter* has led to definite plans for building a prototype system, and the assignment of personnel and procurement of equipment began. ALRI would extend contiguous high- and low-altitude radar coverage from the present limits of SAGE further out to sea. Aircraft equipped with improved radar (long range and height), improved communications and navigation equipment, and a data processing system similar to the present AN/FST-2 would make possible SAGE air surveillance, identification, and weapons control seaward to a distance of roughly 300 miles from the coast at both high and low altitudes. The design, construction, and testing of ALRI is a joint effort of Groups 60, 62, 63, 67, 25, 45, and others.† Group 62 is primarily responsible for the design and construction of the airborne data processor.

A laboratory prototype of the airborne data processor is being built which will receive quantized radar data from an AEW-type aircraft and prepare it for the LRI (long range radar input) frame in AN/FSQ-7 (XD-1) where data from ESS long range radars is now received. Accurate comparisons of airborne and ESS radar registration will then be made. In the interests of early experimental operation, no effort will be made to construct a highly compact, lightweight data processor for the first airborne model. It will be built up instead from the laboratory prototype, which uses printed cards and sub-racks similar to those developed by Division 2 for its CG24 computer and plug-in units now in production for Group 63's TX-2 computer. The principal differences between the airborne data processor and the AN/FST-2, which performs a similar function in SAGE LRI sites, are (1) it employs transistor circuits, and (2) its target detection logic is different because of the wider beam width of the airborne radar antenna.

Although the prototype ALRI system will utilize existing equipment to a large degree, modifications will be required to meet the requirements of the system. The following are the more important projects underway:

---

*Quarterly Progress Report, Division 6, Lincoln Laboratory, MIT (15 March 1958), Sec. II, D.

†See Sec. VII, B of this report for an ALRI system description.

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(1) Video Quantizer: Repackage existing AN/FST-2 quantizer for airborne use with the APS-70 radar.

(2) Digital Target Detector: Design logic and construct the detector, using advanced circuits evolved from the TX-2 experimental computer, and construct a ferrite core memory (1024-registers, 36 bits) employing transistor plug-in units like those now being installed in TX-2.

(3) Write a simulation program to investigate radar noise distribution; set parameters for target detection logic and beam splitting.

(4) Magnetic Tape Recorders: Develop reliable systems for recording quantized video data on the aircraft and at the laboratory data processor; the airborne recording will be played back later as controlled input to the laboratory data processor to permit a study of the effects of parameter change. Bit densities of 167,000 per second will be sequentially distributed on ten tape tracks by the use of an electronic commutator.

(5) Airborne Mapper: Modify a standard B-scan display scope to operate a full 360 degrees and combine it with a photomultiplier for use as a radar mapper; scope will also be used as a test pattern generator, a memory tester, and a detector monitor.

C. COORDINATION OF ESS MAINTENANCE

Group 62 provides liaison between the users of ESS and those responsible for maintaining ESS equipment. They provide the users with a system that has been tested for use and which has the desired program operating in the computer. Test programs and special test equipment are devised to ascertain that the system is operating properly or to locate malfunctions in it.

1. Utility Diagnostic Active System (UDAS)

The development of a family of programs under the general heading, Utility Diagnostic Active System (UDAS), continued in an effort complementary with that of IBM. UDAS will detect system failures while operating in real time with the DCA program, obtain pertinent information about the failure, and in certain cases take immediate corrective action.

During the quarter six new UDAS programs were planned by Group 62 (see below) and the preliminary design of logic was begun. IBM continued writing a group of programs called Fix and observed encouraging results in preliminary tests with some of them during shakedown. Fix contains four automatically operated programs: drum parity, memory parity, output alarms, and inactivity (e.g., unprogrammed halts). In particular, Fix prevented bad-parity messages on the input drums from entering the memory, thus avoiding interruptions in the mission. It also logged pertinent information for maintenance purposes.

The chief value of UDAS programs will be in obtaining information for later diagnosis and correction on problems that arise during a mission, without interrupting the mission. Such information is used by the maintenance coordinator to assist the agency responsible for the malfunctioning system element. Four main functions will be performed by UDAS. It will:

(1) aid in detecting troubles in the system

(2) obtain useful maintenance data on problems that arise during the mission without interrupting the mission

Unclassified

(3) compensate automatically for failures that occur during a mission, whenever possible

(4) automatically initiate startover procedures, whenever necessary and possible.

The programs of UDAS fall into two categories: automatic (the IBM Fix programs), and manual (the Group 62 programs described below). In general, the automatic programs deal only with failures in the computer while the manually operated programs, called in by the maintenance coordinator, help diagnose difficulties in all system equipment.

(a) Frequency-Division Data Link Program

This program will send a predetermined message over a selected data link channel. The message will be monitored at the data link transmitter for comparison. If desired, the teletype will post the identity of all aircraft taken off of data-link control so that test messages can be sent over those channels.

(b) Light Gun Program

Upon the request of a console operator, this program will display a piece of test data on the situation display of that console only. The light gun will then be used on the test data and the program will determine whether the light gun message is correctly received by the computer.

(c) Radar Registration Program

Targets in the overlap area between two radars will be selected by means of light gun: the differences in the positions of the targets as seen by the two radars will be logged, and the maintenance coordinator will estimate the orientation error by examining the data. Corrective action will be taken after the test.

(d) Digital Display Program

This program will display a predetermined message on the digital display tube of the selected console. The operator will check the display visually for correspondence with the predetermined message.

(e) Utility Diagnostic Recording

This program is essentially a modification of the assembly test recording system now in use. The modifications will give the operator more control over what to record, when to start, and when to stop at any time during the mission. The present assembly test recording system requires that the operator know in advance of the mission what and when to record.

(f) Height Program

This program will cause the height requests and replies of a selected height finder to be logged. It may also send test messages to the selected height finder.

D. EQUIPMENT DESIGN SUPPORT

New indicators and alarms were designed for the maintenance coordinator which will tell him the status of test switches and alarms on various frames of AN/FSQ-7 (XD-1). At present it is impossible to obtain this information, much of which affects computer operation, without going to the frame in question. In the new design, a panel of lights at the maintenance console

will indicate the positions of the test switches, and audible signals under the panel will duplicate alarm conditions on the input-output frames. Audible alarms will differentiate between computer malfunctions and operator or program errors.

An important design feature is the use of pluggable units for most of the indicators, signals, and alarms. This feature will make it easy to change the panel to match future modifications in the system and changes in maintenance techniques.

DIGITAL COMPUTER DEVELOPMENT

GROUP 63

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CORDERMAN, C.L., *Associate Leader*

GOODENOUGH, J.B., *Associate Leader*

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CLARK, W.A., Jr.
COWGILL, URSULA M.
CROWTHER, T.S.
DOWNING, J.L.
DUGGER, C.O.
DWIGHT, K., Jr.
ECKL, D.J.
ELLIS, D.H.
EPSTEIN, M.A.
FADIMAN, J.R.
FARLEY, B.G.
FERGUS, PATRICIA A.
FERRETTI, A.
FORGIE, J.W.
FRANKOVICH, J.M.
GILMORE, J.T., Jr.
GOULD, R.H.
GUDITZ, E.A.
GURLEY, B.M.
HERNDON, T.O.
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JOHNSON, T.G.
JOHNSTON, R.C.
JOSEPHS, J.J.
KIRK, C.T., Jr.
KONKLE, K.H.
LARSON, E.G.
LIN, C.S.
LOEB, A.L.
MAYER, R.P.
MENYUK, N.
MITCHELL, J.L.
MOON, R.M., Jr.
NEUMANN, L.
PETERSON, H.P., Jr.
RAFFEL, J.I.
SARLES, F.W.
SAVELL, R.E.
SHOULDERS, K.R.
SMITH, D.O.
STOCKEBRAND, T.C.
UNDERWOOD, D.I.
WEISS, G.P.
WICKHAM, D.G.
WOLD, A.
ZIEGLER, H.L.
ZIEMAN, H.E.
ZOPATTI, R.C.

III. DIGITAL COMPUTER DEVELOPMENT
GROUP 63

A. SUMMARY

Preparations have been almost completed for the scheduled transfer of the TX-0 experimental computer to M.I.T. late in June. Meanwhile assembly of the TX-2 general purpose transistorized computer with the 256^2 memory has continued. Most of the central computer has been wired and limited operations are being carried out.

Thin film memory development has advanced to the point of constructing a prototype memory with two 32×16 arrays which is now under test. Development has been aided by a pulse tester and sense amplifier which have been recently designed and built to study the magnetic characteristics of individual spots in a thin film array.

Electroplated circuit connections are being investigated as a substitute for solder lugs or eyelets to increase the possible component density in electronic packages. In a recent test electroplated connections successfully withstood temperatures that softened conventional solder connections.

A typewriter keyboard input for the TX-2 computer has been designed to give the programmer a significantly broader and more convenient means of expressing himself to the computer than has been previously available. A complete description of the computer-integrated high speed magnetic tape system developed for TX-2 is included in an appendix to this report.

An appendix to this report to be found on page 26 presents the summary of progress of the Magnetic Materials Section of Group 63. The complete report will be found in "Quarterly Progress Report, Solid State Research (1 March 1958 to 31 May 1958) Lincoln Laboratory, M.I.T. Groups 24, 35, 37, 63, 310 (Unclassified)."

B. TX-0, TX-2 ENGINEERING

1. TX-0

Preparations have been almost completed for the scheduled transfer of the TX-0 experimental computer to M.I.T. at the end of June. Included among the major sections which were installed and whose operation was verified during the quarter were:

Power control and voltage monitor
Power distribution
Flexowriter and photoelectric tape reader
Transistor driven core memory (TDCM)
Marginal check panel

Programmers have agreed on a larger and more generally useful instruction code than was available with the original TX-0 and are now preparing and testing new routines on the computer.

2. TX-2

All of the central computer has been wired except for a few necessary modifications indicated by errors discovered during checkout. Limited operations have been made possible by the

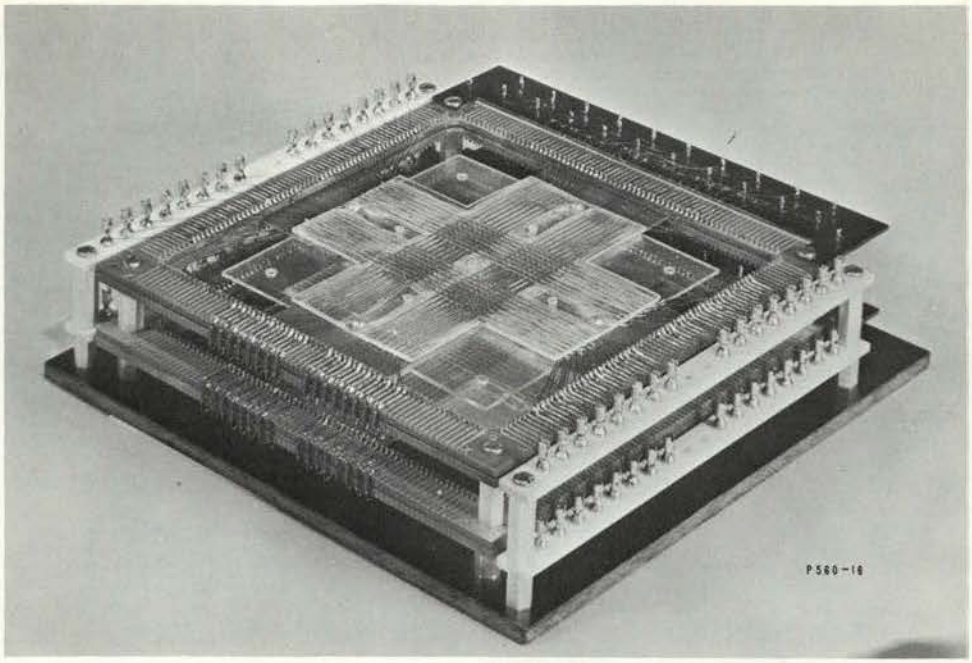

Fig. 63-1. Prototype thin film memory consisting of two 32 by 16 planes.

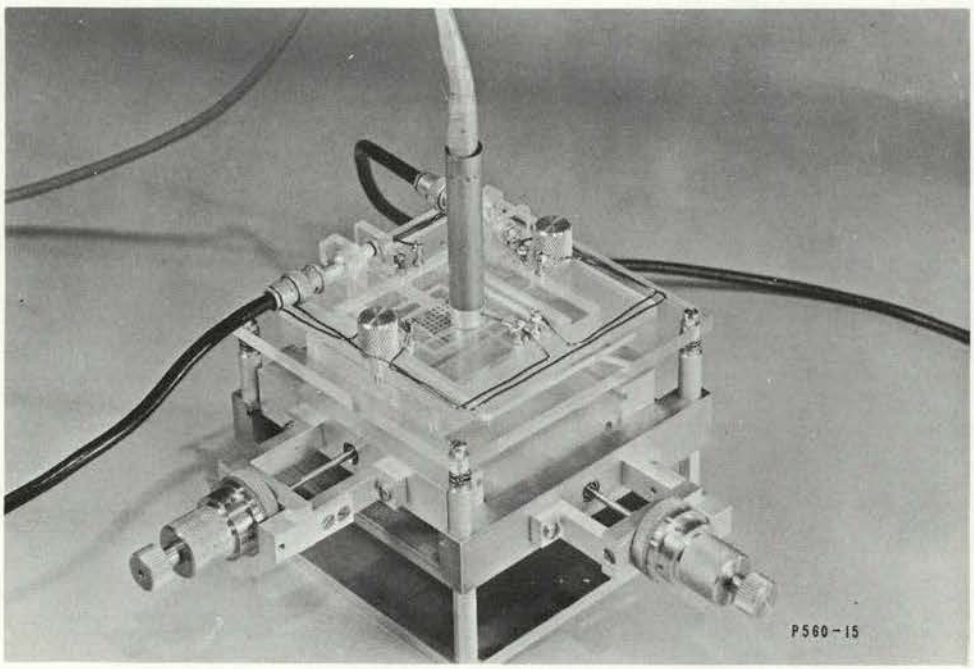

Fig. 63-2. Thin film pulse tester.

completion of the index memory, the toggle switch storage system, and the modifications to the 256^2 memory necessary for full 36-bit operation. Among the items assembled and now under test are:

Configuration control section
Power wiring for E and F frames
Program counter

Some items still under construction or being assembled include:

In-out buffer mixer outputs to E register
Marginal check panel
Photo-electric tape reader modifications
Wiring for interlock control, memory select, and start-stop levels

C. THIN FILM ENGINEERING

1. Films

Standard sizes have been determined for the glass substrates on which thin films are deposited. Eight by eight arrays will be deposited on 0.800" square substrates and sixteen by sixteen arrays will go on 1.600" squares. Both plate sizes will be provided in thicknesses of 0.002", 0.006", and 0.040". Several hundred of each size and thickness have been received and will be used when the proper masks and holders have been constructed.

2. Memory

A prototype thin-film memory with two planes 32×16 (Fig. 63-1) has been completed and is under test. Noise induced in the sense winding by transient currents through the digit plane driver line to ground was apparently eliminated by grounding the secondary of the cores. Tests are continuing.

3. Pulse Tester

A pulse tester (Fig. 63-2) has been designed and constructed to determine magnetic characteristics such as disturb levels and skew of the individual cores in an array of thin films. Data taken on the pulse tester will contribute to the objectives of more uniform and more reproducible films. In the pulse tester a cross-slide arrangement accurately positions the selected spot at the intersection of transverse and longitudinal pulses. The film output pulse induces in a pickup coil a voltage which is amplified and fed into an oscilloscope for observation and recording.

4. Sense Amplifier

The design of a breadboard model of a differential amplifier for sensing thin-film outputs has been previously described.* This amplifier has now been packaged in a plug-in unit (Fig. 63-3).

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* Quarterly Progress Report, Division 6, Lincoln Laboratory, M.I.T. (15 March 1958), Section III, B, 3.

P488-74

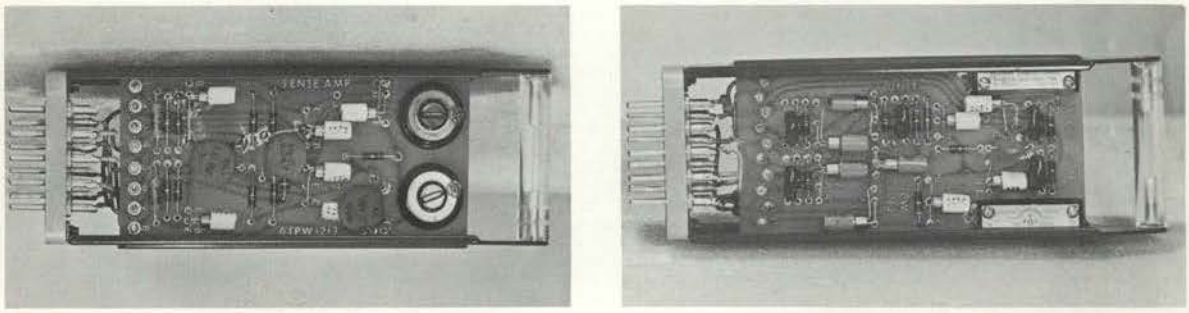

Fig. 63-3. Thin film sense amplifier plug-in units.

The characteristics of the completed unit that have been determined so far include:

Frequency response linear from 0 – 30 mc.

Voltage gain for three stages is approximately 1000
(1 volt output from an expected 1 mv input)

Voltage margins compatible with TX-2 requirements.

Further testing is planned for next quarter.

D. ELECTROPLATED CONNECTIONS

Techniques of electroplating circuit connections to avoid the bulk and weight of solder lugs are being pursued as an outgrowth of the encouraging results obtained in three-dimensional printed wiring. Maximum component density would be achieved if circuit wiring could be placed on the surface of an encapsulated circuit. Experimental evidence indicates the feasibility of plated connections. In a recent test, a block containing 16 plated connections (Fig. 63-4) made almost 13 months ago withstood a temperature of 183°C, the melting point of eutectic solder. At that temperature the soldered input wires to the test block came loose. They will be replaced by clamp connectors for further tests at higher temperatures. More recent samples (Fig. 63-5) have failed high temperature tests due, apparently, to thermal expansion of the encapsulant. Other test blocks are being constructed of materials with lower thermal coefficients of expansion.

E. TAPE DRIVE

The design and construction of the high speed tape machine with random access for TX-2* has been completed. Up to 100 individual transports can be controlled by a central electronic system. High speed search rates up to 920 inches per second make any one of 10^{10} bits of the stored information available within about 30 seconds. Read and write speeds are from 30 to 100 inches per second. The new tape drive is described in detail in 6M-5701 which is included as an appendix to this report.

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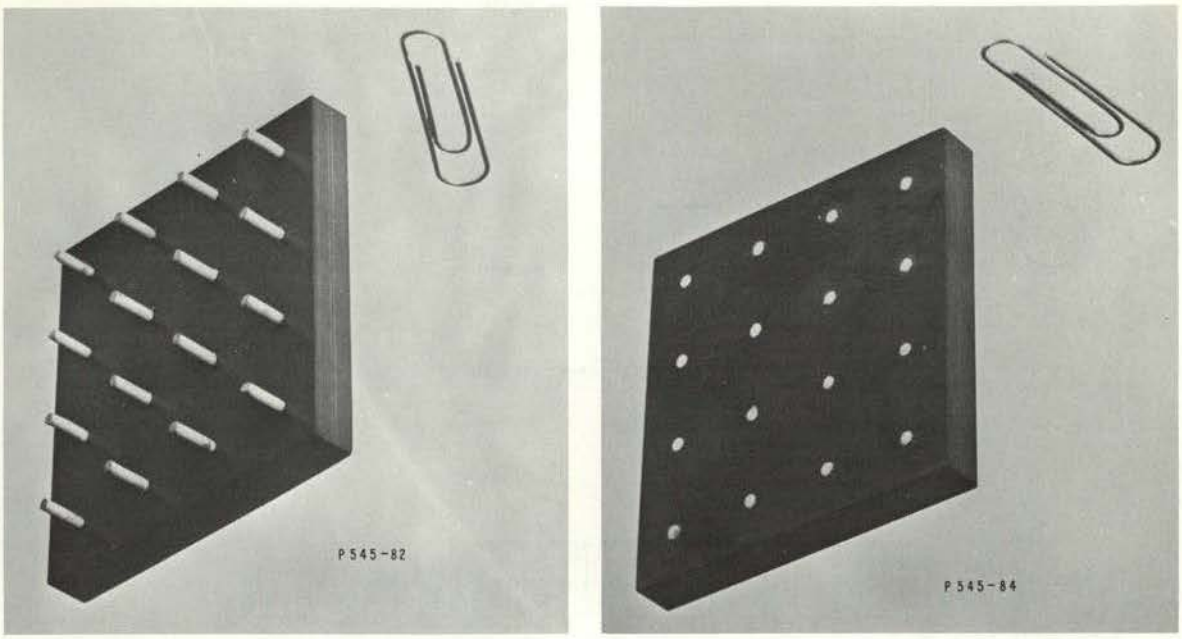
* Quarterly Progress Report, Division 6, Lincoln Laboratory, M.I.T. (15 December 1957), Section III, C, 2.



(a) (b)

Fig. 63-4. Front and back views of plated connection test block.

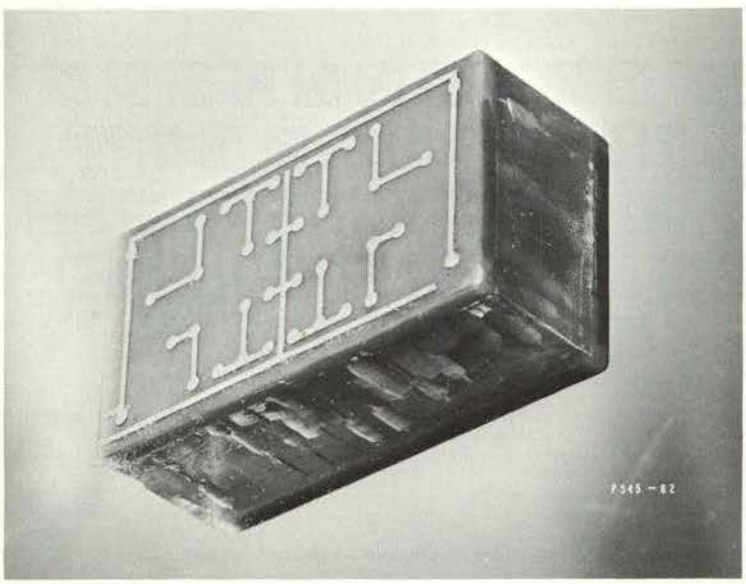


Fig. 63-5. Encapsulated circuit test block for plated component connections.

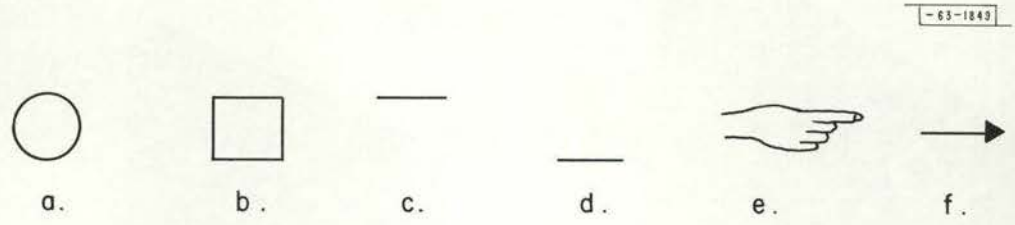


Fig. 63-6. Special characters for Lincoln keyboard.

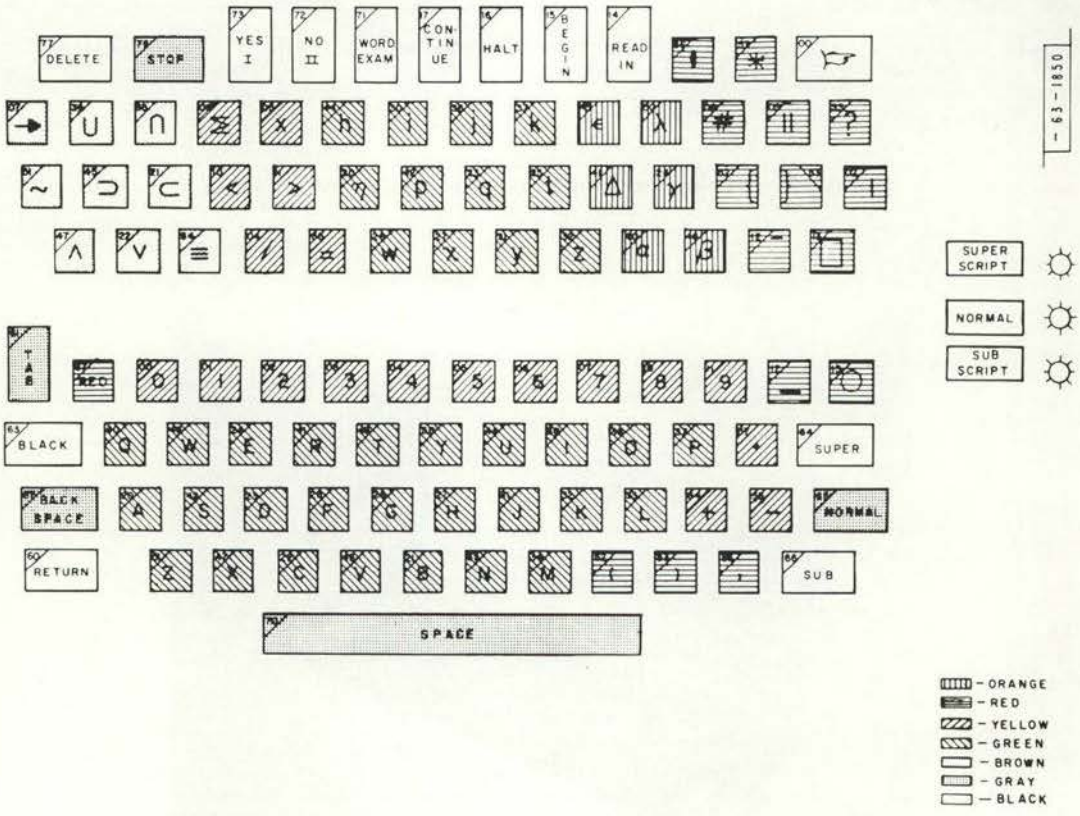


Fig. 63-7. Lincoln keyboard layout.

F. TX-2 PROGRAMMING

TX-2 programmers will be able to communicate with the computer through a typewriter input with 88 of the characters most useful to them. Chosen by means of the Lincoln Scopewriter,* the characters of the new keyboard will include English alphabet, Arabic numerals, Greek letters, symbolic logic notations, arithmetic symbols, and a number of extra machine functions. Block letters and Arabic numerals are in the standard keyboard locations; all other characters are located for maximum convenience.

Four of the special symbols [Fig. 63-6(a, b, c, d)] do not advance the typewriter carriage and can therefore be used to enclose, underline, or "bar" the next character typed. The "period" prints in the center of the character space and is perhaps more properly called a "dot" (as in "dot product"). The character shown in Fig. 63-6(e) has been called the "Meta Hand" and is used to indicate an aside. Figure 63-6(f) is a printed arrow and not a machine function.

The programmer-typist will not have to concern himself with shifts of the type case. Two complete keyboards (Fig. 63-7) allow a separate key for every character and machine function. Color coded keys will further assist the programmer who is not a skilled typist. Green keys are English alphabet characters; yellow, arithmetic; brown, symbolic logic; orange, Greek; red, punctuation; gray and black are for machine functions and special characters.

The complete unit will incorporate an IBM electric typewriter modified by Soroban Engineering, Inc., a mechanical paper tape reader, a paper tape punch, and a central control unit (Fig. 63-8).

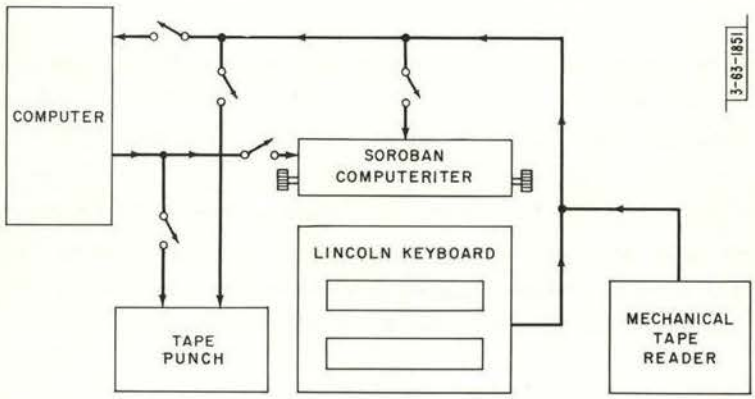


Fig. 63-8. Lincoln keyboard communications channels. The complete typewriter input-output for the TX-2 will provide a direct input to the computer with or without a concurrent typed or punched tape printout. Similarly the computer will communicate with the programmer by typewriter and/or punched tape. Duplicate tapes and/or typewritten copy can be had by feeding an original tape through the mechanical tape reader.

* Quarterly Progress Report, Division 6, Lincoln Laboratory, M.I.T. (15 December 1957), Section III, D.

APPENDIX
A COMPUTER-INTEGRATED, RAPID ACCESS, MAGNETIC-TAPE SYSTEM WITH FIXED ADDRESS

I. INTRODUCTION

This Appendix describes the internal tape library system planned for the TX-2 computer at Lincoln Laboratory, MIT. One hundred magnetic tape transports will be under the control of a central electronic system; the system will have a storage capacity of 10^{10} bits and an access time of about 30 seconds. It is particularly well suited for use with a computer of large random-access storage capacity such as TX-2, which has a core memory of 2-1/2 million bits. A simple tape transport having a high speed search mode with redundant information transfer will make the ultimate library system reliable and relatively inexpensive.

The tape transports are controlled by electronic circuits closely integrated with the computer. A permanent, constant-density timing track on the tape provides the speed reference for the control circuits and makes possible fixed position addressing and a variable rate of information transfer. The transport does not employ a constant speed capstan: two conventional three-phase motors pull the tape in either direction. The control system varies the speed by modifying the torque on the driving motors after comparing the timing track bit rate with the desired bit rate. By this means, the computer can select an appropriate speed for recording data in real-time over prolonged periods. A separate channel of block marks enables the computer to locate information blocks at any speed, including high-speed search at 920 inches per second (ips). Read and write speeds are 30 to 100 ips and acceleration time to these speeds is 1/2 to 1-1/2 seconds.

High reliability in the transfer of information to and from the tape is gained by making five channels out of ten redundantly paired tracks. Thus in the ten-track head assembly there are three information channels, one timing channel, and one block mark channel. Appropriate head shielding reduces crosstalk and permits reading of the timing channel when other channels are being used for writing. Since the amplitude of the signal from the tape varies greatly with speed, a system of recording is used that allows the polarity of the flux change, rather than its amplitude, to be sensed in reading. High gain amplifiers may then be used in which the output stages are normally saturated and the gain need not be closely controlled.

II. COMPUTER/TAPE LIBRARY RELATIONSHIP

The primary objective – a large library of quickly accessible information – is provided by a large number of tape transport mechanisms controlled by a small number of circuits which are closely integrated with the computer. One feature of TX-2[1, 2] is its multiple sequence control; that is, it can share its attention between equipments which are operating simultaneously in real time. The computer commands the selected tape drive to attain some mode of operation, then turns its attention elsewhere until the tape control tells the computer that the desired mode has been attained. Multiple sequence control also enables the computer to vary the speed of the tape during information transfer: this feature would be used, for example, if the computation

itself depended upon external, real-time events and the information transfer had to be synchronized with the results of the computation.

Another feature of TX-2 is its large, random access, core memory[3] which can store large blocks of information at one time and which can be used as a buffer while the tape is accelerating. The control element for the tape library accepts the computer's commands rapidly but does not require instant response by the computer to events in the tape system. Generally the control takes care of the simple local problem and leaves the complex problems of operation to the computer – and therefore the programmer.

The tape mechanism, which has a wide variety of speeds, can search through a reel of tape much faster than the computer can accept information. For this reason, blocks of information on the tape are tagged with block marks that can be read at speeds up to the maximum – 920 ips. The read and write instructions command only a single 9-bit transfer between memory and tape. A series of such instructions is necessary to transfer large blocks of information; the instructions must occur at an average rate determined by the tape's speed.

III. TRANSPORT DESIGN AND MOTION CONTROL

1. Mechanical Design

The tape transports used in this system were made as simple and foolproof as possible: they consist of a read-write head assembly, two reels, two drive motors, and a tape guide. The drive mechanism has no capstan. Thus a good deal of mechanical complexity is eliminated and a wide range of tape speeds is made possible. Fast starts and stops are precluded, however: 1/2 second and 7-1/2 inches of tape are required to reach 30 ips.

Figures 1 and 2 show the transport mechanism. The motors are flange mounted, 1800 rpm, three-phase induction motors of the conventional type which have roughly constant torque characteristics when operating well below synchronous speed. The hp rating, and therefore the torque, is as high as possible, limited by the tensile strength of the tape. One-eighth hp motors, each driven by a magnetic amplifier, provide the proper torque to operate ten-inch reels mounted directly on the motor shaft and loaded with polyester tape, .001-in. thick and 1/2-in. wide. Maximum tape speed is about 920 ips when the driving reel is full.

The head assembly and guide are shown in the insert, Fig. 2. The relatively large, constant radius of the guide reduces the pressure between tape and guide: At speeds above 20 ips the tape floats on an air cushion and is thus easy to edge guide. Skew, caused by non-uniform tape tension across the width of the tape and by variations in tape width, is minimized. There is no wrap around the head. Variations in tape tension (which are large in this transport) do not, therefore, cause excessive pressures on the head and wear is reduced. Because only short wave lengths (.010 and .005 in.) are used in the system, the area of tape-head contact need not be large.

The direction in which the transport is moving is determined by a sensing device mounted on the rear shaft extension of one motor. The sensor consists of an iron cup dragged against one of a pair of stops by hysteresis from a star shaped permanent magnet on the motor shaft. The cup operates a mercury switch by rotating an attached magnet. This scheme gives positive

direction information even at the slowest tape speed. A mercury wetted contact switch provides computer-level signals to the control without contact bounce and with good reliability.

2. Motion Control

Each motor can generate torque in only one direction to pull the tape from one reel to the other. The control of the motors is therefore simpler than if torque had to be reversed. Since tension is limited by tape strength, acceleration is relatively slow. A sudden change of torque, which might allow a loop to form, is prevented by a long time constant in the control windings of the motor magnetic amplifier.

To stop the tape, full torque is first applied by the trailing motor until the tape speed falls below 20 ips: at that point dc is applied to the trailing motor to bring the tape to a smooth stop. The direction sensor indicates which motor is trailing. With dc in the motor field winding the rotor will resist applied torque even at zero velocity due to the hysteresis in the rotor. Voltage is never completely removed from either motor in order that some tape tension always be maintained. The end of the tape is sensed by a photoelectric cell which receives light through transparent leaders at each end of the tape. The timing track is continued on the edges of the 100-ft. transparent strips so that the control element will know when the tape has fallen below 20 ips as described above.

The control circuit for one of the motors is shown in Fig. 3. The transistor, Q-1, regulates the current through the control windings of the three-phase magnetic amplifier, and it switches between saturation and cutoff at various duty cycles. When Q-1 is cut off, D-1 conducts, so that the control winding time constant is determined solely by its own inductance and the 470 ohm resistor. This time constant is made long enough to prevent abrupt torque changes and to average the control current.

Feedback was included to provide close control of minimum torque. Too much minimum torque will either allow the tape to creep or require excessive dc holding currents in the trailing motor. Too little torque will fail to overcome static friction, and allow a loop of tape to form. The feedback prevents large variations in the output current of the magnetic amplifier which would be caused by unbalanced line voltage or small variations in reactor control current – especially when the amplifiers are nearly cut off. The feedback signal is derived from the sum of currents in all three motor leads. The diode D-2 limits the sum output voltage of the current transformers to 10 volts and thus keeps the voltage drop across their primaries negligible under high current conditions. To generate full torque, one of the other transistors such as Q-3 is saturated, cutting off the magnetic amplifier control current independent of the feedback and allowing full current to flow to the motor.

The direct current which is applied to the trailing motor when the transport is slowing to a stop is switched to one lead of the motor by a relay contact (not shown on Fig. 3). The dc flows into that motor lead and out the other two, back through the magnetic amplifiers. Although the magnetic amplifiers are biased into a low torque condition they will pass the dc (approximately 1 amp) since the average voltage across any one reactor must be zero.

3. Digital Speed Control

To determine which motor should receive full torque, minimum torque, or dc, the desired condition of the transport is compared with the existing one. As shown in Fig. 4 the motion control is based on a group of speed domains: Too Fast (f), Faster Than Controlled (f_c), Slower Than Controlled (s_c), and Too Slow (s). Various torque commands are shown as a function of speed and direction for several desired conditions.

The speed sensing logic is diagrammed in Fig. 5. The speed is detected by comparing the interval between timing pulses from the tape with the delays of delay units, as shown in Fig. 6. Two pulses are generated from a tape timing channel as it travels over the head (6a and 6b). The first is used to fire three delay units, two of which (6c and 6f) establish the boundaries between the area of usable speeds and "too fast" or "too slow." The third delay unit (6d) can be set by the computer to any one of several delay times representing speeds in the useful range and provides close speed control at preset and selectable tape speeds. It in turn drives a fourth delay unit (6e) to provide a controlled zone. In this condition the transport coasts. The second timing pulse occurs at a time determined by the speed of the tape. It is used to sense the condition of the delay units and to set flip-flops to define the speed domain. It is also used to reset the units so they have time to recover before the next "set" pulse. The dotted wave forms in 6e and 6f indicate this resetting when the tape is in the controlled speed zone. The delay units must be resettable, and the delay time of one must be capable of electronic variation.

IV. HEAD ASSEMBLY AND READ-WRITE METHOD

1. Head Assembly Design

The ten-track head assembly contains five channels: three information, one timing, and one block mark. Each channel consists of two redundantly paired tracks; the tracks in each pair are non-adjacent to minimize the effect of a speck of dirt lifting a portion of the tape. The timing channel occupies the two outside tracks which are heavily shielded from the interior ones in order that the timing channel may be read while the others are being written.

The timing channel controls tape speed, information density, and the fixed address feature. It assures constant information density regardless of tape speed and makes possible the changing of a single word in a message. Its density must therefore be known and constant. It is permanently recorded, either with a constant speed capstan temporarily attached or on a separate, constant speed machine.

2. Read and Write Principles

Since the amplitude of the signal from the tape varies greatly with speed, a system of recording is used that allows the polarity of the flux change to be significant rather than its amplitude. High gain amplifiers may then be used in which the gain need not be constant. Figure 7 shows the flux pattern and other waveforms. The idealized timing track flux pattern (7a) consists of 200 complete cycles of flux per inch, or 400 flux reversals per inch. The timing track read voltage (7b) is the expected derivation waveform from a .0005-in. gap looking at a signal of this density. The signal is amplified and squared in a Schmitt circuit (7c); the finite

hysteresis of the Schmitt circuit delays the signal slightly as shown. Time pulses are generated from the transitions of the Schmitt circuit – time pulse 0 (TP0) from the negative transitions and time pulse 1 (TP1) from the positive transitions (7d and 7e). The time pulses must then be slightly delayed (7f and 7g) so that the information flux pattern may be written in phase with the timing flux pattern. The delay is a function of tape speed and is varied by an analog voltage fed to the delay circuit. The analog voltage is in turn derived from a circuit whose output is a predetermined function of the average frequency of the time pulses fed to it. The flux is laid on the tape in phase with the timing flux so that information may be read or written while the tape is moving in either direction.

The delayed time pulses control the transfer of information to the writing flip-flops. Delayed TP0 transfers the bit to be written to the flip-flop which is controlling write current; delayed TP1 complements the flip-flop. Thus a flux change is written in the center of each line corresponding to the bit to be written; there may or may not be flux changes between the lines. A typical information pattern and resulting ideal flux pattern are shown in 7h and 7i. The voltage which would be read from the above channel during read time is shown in 7j. Notice that there is a saturation signal at the center of each line, while in between lines there is sometimes a signal and sometimes not. The signal is then amplified more than necessary (7k). The amplifier has enough gain so that one of the redundant tracks may be completely separated from the head by a speck of dirt while a half-amplitude signal is being received from the other track – a saturation signal will still be delivered by the amplifier at the center of the line. The amplifier is strobed by delayed TP1, so that the logic doesn't know what the amplifier output looks like at any other time. The saturation output received at the center of each line with phase modulated NRZ recording also allows the tape to be read correctly with plenty of amplifier gain margin over a wide range of tape needs.

3. Read and Write Circuits

The read-write switch and write circuit for one digit are shown in Fig. 8. During WRITE, Q4 is cut off and Q3 is saturated. With Q4 cut off, its 10K collector resistor lifts the bases of Q5 and Q6 towards +30, leaving them cut off and the read amplifier disconnected. The silicon diodes at the amplifier input prevent any large voltage excursions from reaching the amplifier. With Q3 saturated, the digit flip-flop will cause either Q1 or Q2 to also be saturated. With the circuit values shown, 15 ma. will flow through the two series-connected tracks and 30 ma. through the saturated transistor (Q1 or Q2). The direction of current flow through the tracks is determined by the flip-flop state; i.e., whether Q1 or Q2 is saturated.

During READ, Q3 is cut off and Q4 is saturated. Q4 takes the full write current through diodes D5 and D6, back biasing diodes D1 through D4. With Q4 saturated diodes D7 and D8 are back biased, allowing Q5 and Q6 to be saturated, thus connecting the 2 series-connected tracks to the read amplifier at a dc level of approximately zero.

4. Read Amplifier

The read amplifier (Fig. 9) has two difference-amplifier stages and one output stage with more than enough gain to give a saturation output signal at a tape speed of 20 ips. In the first

two stages, the common mode gain per stage is less than unity while the difference signal gain is approximately beta. The low common mode gain insures that power supply noise will not be amplified. Each transistor (Q1 – Q4) is biased to a constant dc operating point of approximately 3.8 emitter-collector volts and 1.9 ma collector current. The capacitors shown must only be large enough to have negligible signal attenuation at 20 ips, the lowest tape speed of interest. The lowest frequency signal will be at 20 ips and 100 cycles per inch (alternate ONES and ZEROS; see 7j) for a frequency of 2 kc. The highest frequency will be at 920 ips and 200 cycles per inch (all ONES or all ZEROS) for a frequency of 184 kc. The micro-alloy 2N393 transistors have more than enough bandwidth for this application. The signal amplitude at the input to Q5 and Q6 is large enough so that, most of the time, one of these transistors is saturated. The output signals are of a computer-type amplitude (0 or –3) and are sampled by TP1 using conventional TX-2 logical circuits.[4]

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1. J.M. Frankovich and H.P. Peterson, "Functional Description of TX-2 Computer," Proc. of WJCC, February 1957, pp. 146-150.
2. J.W. Forgie, "The Lincoln TX-2 Input-Output System," ibid., pp. 156-160.
3. R.L. Best, "Memory Units in the Lincoln TX-2," ibid., pp. 160-166.
4. K.H. Olsen, "Transistor Circuitry in the Lincoln TX-2," ibid., pp. 167-171.

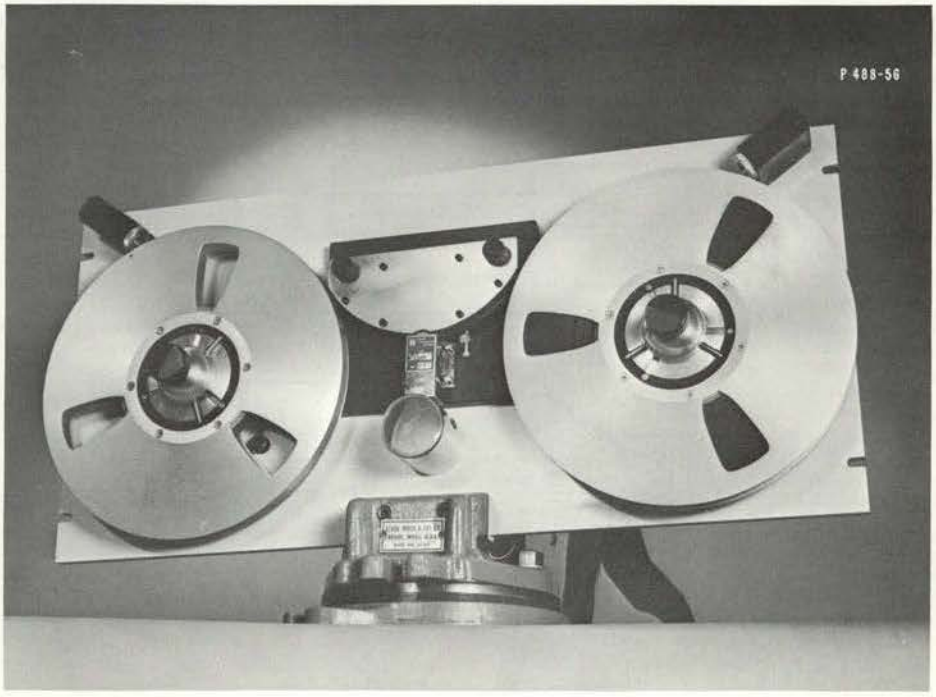

Fig. 63A-1. Photograph of tape transport mechanism.

GROUP 63

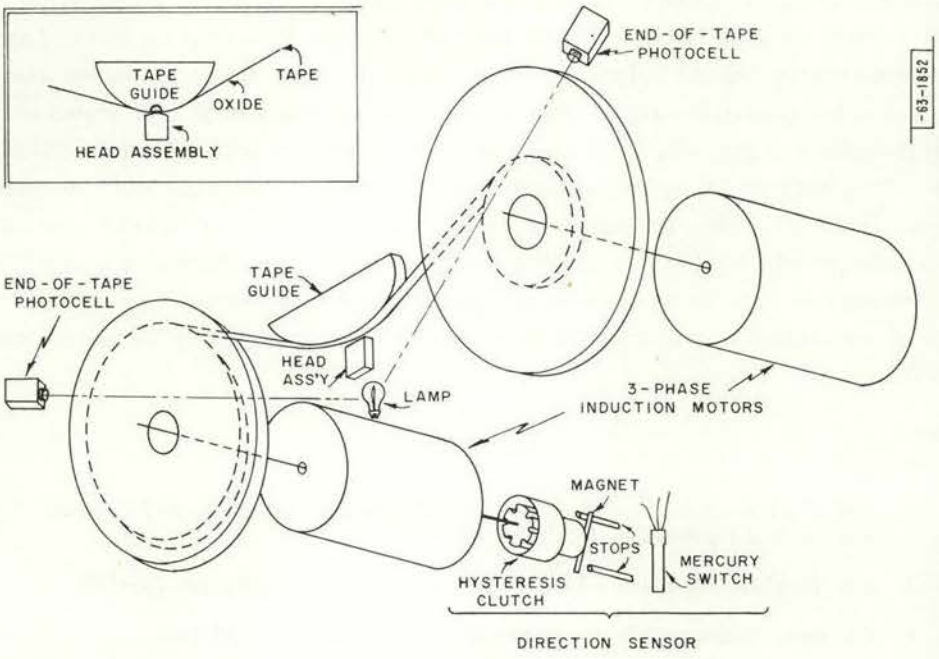

Fig. 63A-2. Tape transport mechanism.

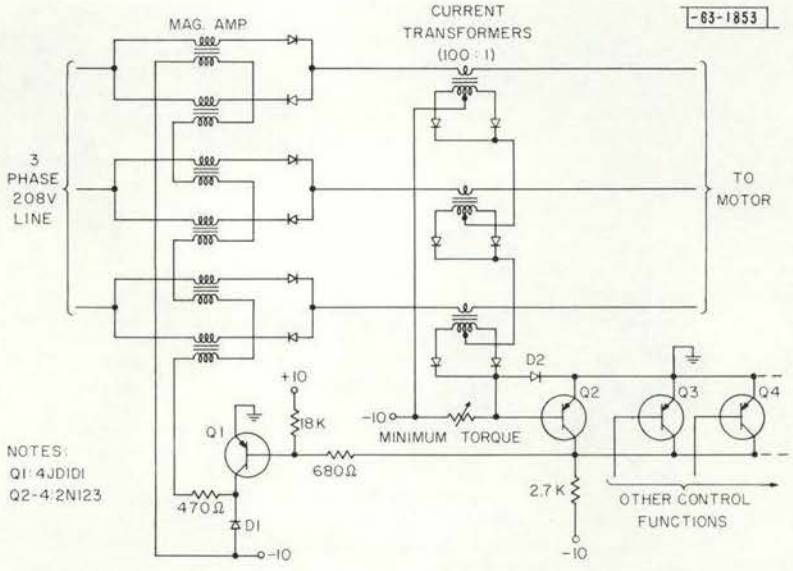

Fig. 63A-3. Motor control.

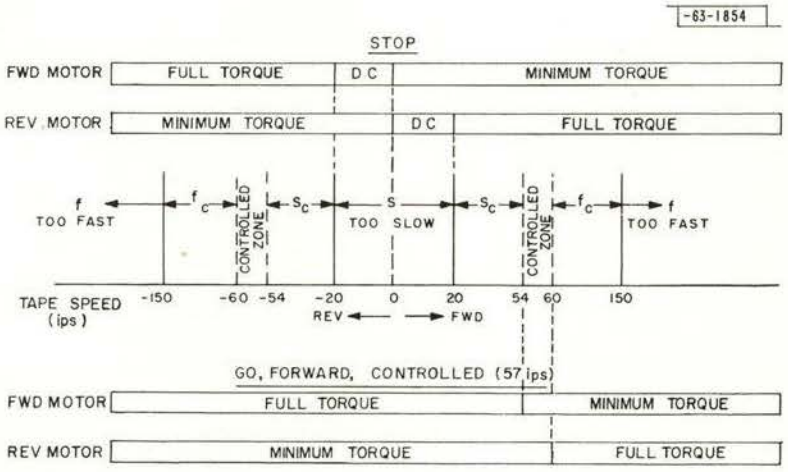

Fig. 63A-4. Motor torque vs. tape speed for several command states.

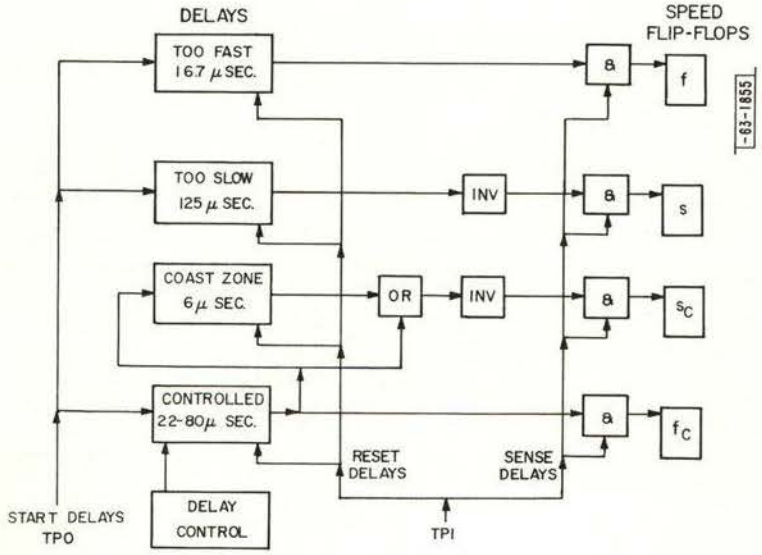

Fig. 63A-5. Speed sensing logic.

GROUP 63

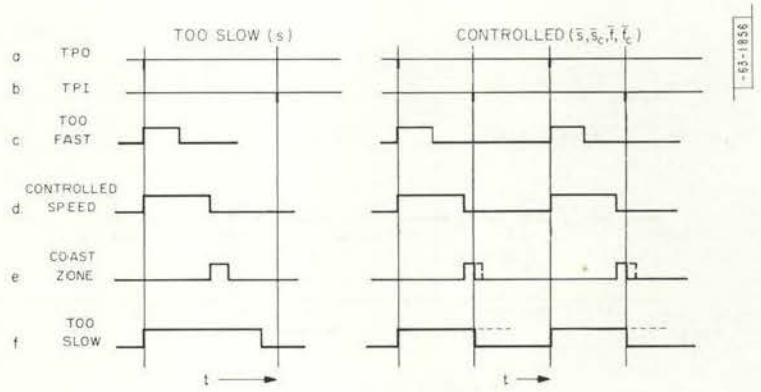

Fig. 63A-6. Speed sensing waveforms.

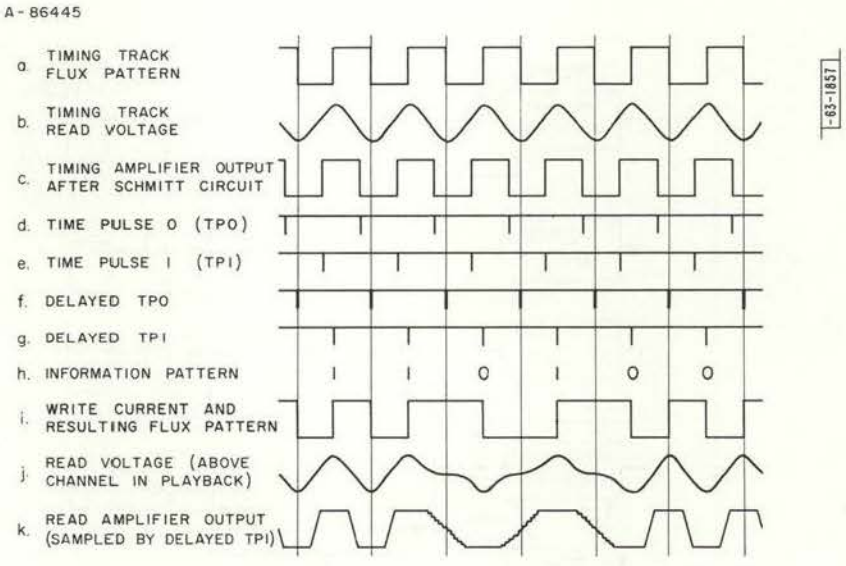
A-86445
a. TIMING TRACK FLUX PATTERN
b. TIMING TRACK READ VOLTAGE
c. TIMING AMPLIFIER OUTPUT AFTER SCHMITT CIRCUIT
d. TIME PULSE 0 (TPO)
e. TIME PULSE 1 (TPI)
f. DELAYED TPO
g. DELAYED TPI
h. INFORMATION PATTERN
1 1 0 1 0 0
i. WRITE CURRENT AND RESULTING FLUX PATTERN
j. READ VOLTAGE (ABOVE CHANNEL IN PLAYBACK)
k. READ AMPLIFIER OUTPUT (SAMPLED BY DELAYED TPI)
-63-1857

Fig. 63A-7. Phase-modulated non-return-to zero waveforms.

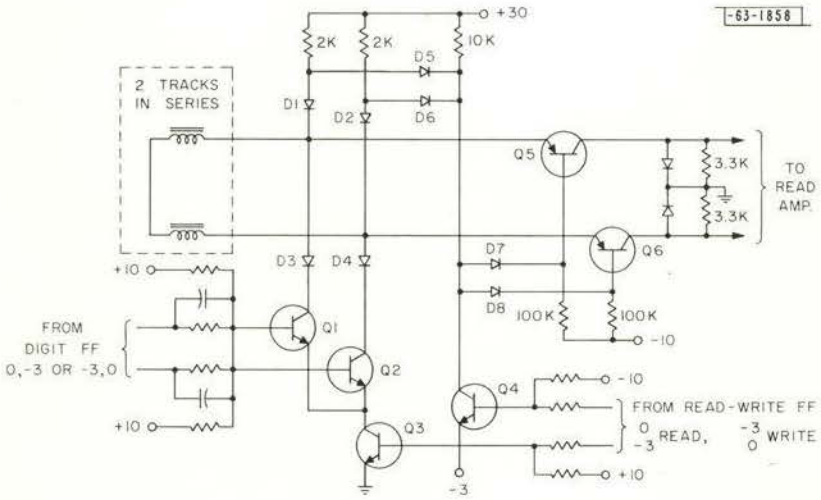

Fig. 63A-8. Read-write switch and write circuit.

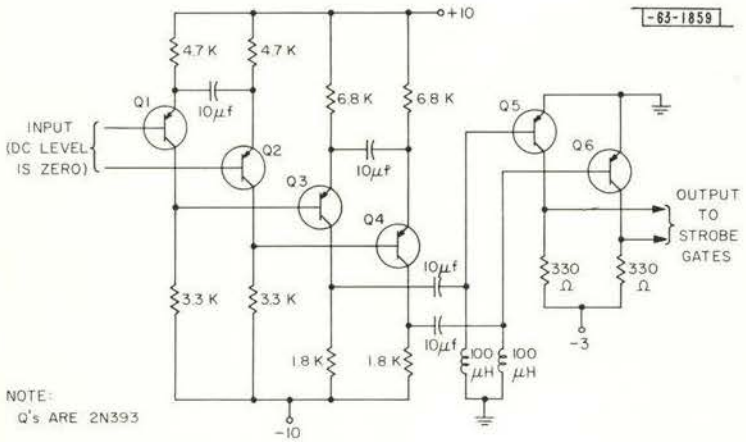

Fig. 63A-9. Read amplifier.

ESS SHAKEDOWN TESTING – MTC OPERATION

GROUP 64

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ESS SHAKEDOWN TESTING – MTC OPERATION
GROUP 64

A. SUMMARY

Twenty-nine system test periods were conducted in the Experimental SAGE Sector (ESS), of which ten employed live aircraft: 14 were for shakedown, 6 for evaluation, and 9 for operator training exercises. Model 1 of the direction center active (DCA) program was tested, with emphasis on verifying improvements in intercept direction, automatic tracking, and crosstell. Assistance was given personnel of the McGuire Direction Center in a critical examination of the system operation. The data processing activities formerly done by the Memory Test Computer (MTC) were given to the IBM 704, and MTC was permanently shut down.

Eight changes in the intercept direction function were found to improve system performance in lead pursuit tactics greatly. Special tests with simulated data provided a comprehensive verification. The shakedown of the crosstell function was concluded after numerous program modifications had made the function operative for testing with simulated inputs.

B. ESS SHAKEDOWN PHASE II

Group 64 conducts tests in ESS for system shakedown, system evaluation, and operator integration. In shakedown, the current version of the system's program is examined, deficiencies are uncovered, modifications are made, and satisfactory system operation is sought. In support of shakedown, the group reduces data recordings and analyzes data resulting from the tests.

The objectives of shakedown testing during this quarter were to:

(1) verify the proper operation of Model 1 of the DCA program

(2) test the intercept direction, automatic tracking, and crosstell functions

(3) improve the proficiency of the operators.

The evaluation of the system is made by Group 22 from data collected in more comprehensive tests designed by Group 64 to measure the performance of the entire system. The results of evaluation testing during this quarter are reported in the Lincoln Laboratory Technical Memorandum, "Experimental SAGE Sector Quarterly Evaluation Report," TM-66-3. Phase I of evaluation testing was completed on 30 April.

The proficiency of ESS Air Force operators of the 6520th AC&W Squadron is improved in tests using simulated aircraft against a background of live radar data. Realistic simulated air battle situations are set up which provide a varying work load for all operators.

1. Test Results

Twenty-nine test periods were conducted during the quarter: 14 were for shakedown (5 using live aircraft), 6 were for evaluation (5 using live aircraft), and 9 were operator training exercises. The tests performed are described in Fig. 64-1, and a breakdown of testing time is given in Fig. 64-2.

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Test No.	Data Input Type	Times Performed	Primary Functions Tested
			SHAKEDOWN
II,4	Simulated	2	Crosstell
II,6	Live	1	Overlap tell
II,13	Live	1	All functions under ECM conditions
II,14	Ampex/Simulated	1	Operation of the computer (after major machine modifications)
II,15	Live	1	Intercept direction
Special	Various	8	Miscellaneous program verification
			OPERATOR TRAINING
OTE* 1-5	Mixed	9	All operator sections; realistic, simulated air battle situations against a background of live radar data.

EVALUATION

Test Date	No.	Strike Penetrations Live	Strike Penetrations Sim.	Peak Strike Load	Interceptor Sorties Live	Interceptor Sorties Sim.	Peak Track Load
5 Mar.	I,21	15	14	19	22	0	81
18 Mar.	I,23	15	14	19	0	38	†
2 Apr.	I,24	12	8	20	0	31	56
9 Apr.	I,26	13	4	13	19	0	58
16 Apr.	I,27	16	0	16	0	30	60
30 Apr.	I,29	14	0	14	0	18	55

* Operator training exercise.

† Figure not available.

Fig. 64-1. ESS system tests performed, 1 March – 31 May 1958.

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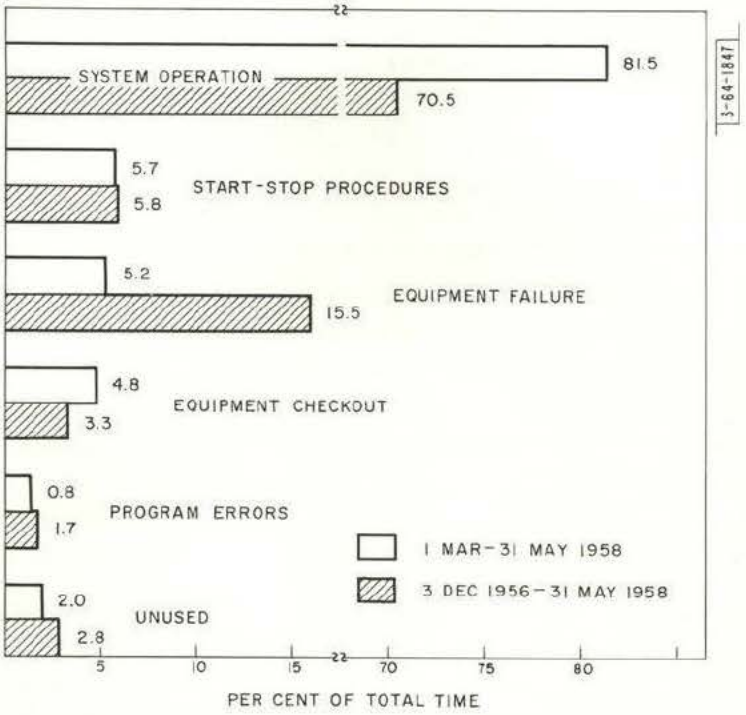

Fig. 64-2. Test time summary – ESS shakedown and evaluation.

Model 1 of the DCA program was tested throughout the quarter with emphasis on modifications to the intercept direction, automatic tracking, and crosstell functions. In May Model 2, which is scheduled for shakedown beginning in June, underwent preliminary examination in cooperation with SDC. Shakedown testing was slowed by a 10-day shutdown of AN/FSQ-7 (XD-1) between 2 and 12 May to permit preparations for the installation of the 65,000-register core memory later in the year.

a. Intercept Direction

A number of corrections were made to the intercept direction function as furnished in Model 1 of the DCA program in order to permit ESS to perform effective air defense. Eight changes to the program were completed in a joint effort with Group 61, SDC, and the 4620th ADW, and were verified in a special ESS shakedown test. This test, conducted on 21 April, used simulated data for a comprehensive verification of the program improvements. Results indicated that the difficulty had been satisfactorily overcome. Further testing in May showed that the modifications improved system performance in final turn intercept tactics slightly, and greatly improved lead pursuit tactics. Initial live testing of this modification is scheduled for June.

The modifications incorporated in the intercept direction functions are briefly described as follows:

(1) Final Turn Tactics: This change makes the turn-in at the offset point less susceptible to the transient inaccuracies of the calculations, resulting in better accuracy in offset distance and approach angles. At two minutes time-to-go to the offset point a counter is started. If the

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counter limit (12 frames) is reached before the interceptor arrives at the offset point, tactics are changed from final turn to the option (lead pursuit or cutoff) specified by the computer or intercept director. In addition, at one minute time-to-go to offset, a time countdown is commenced. Whenever the time becomes less than or equal to 12 seconds, tactics are changed from final turn to the option specified. The first command heading computed after the tactics change is not weighed on the basis of target and interceptor track merit as command headings usually are. Thus, even small heading changes will be sent out immediately.

(2) Lead Pursuit Option: These changes were made primarily to take into account the larger turning radius of the century series interceptors. The displacement associated with this option has been changed from 5 nautical miles to 8 nautical miles and the 15-second lead time has been eliminated from the program. Also, intercept calculations are not frozen at one minute time-to-go to intercept point for this option. Even with these modifications, lead pursuit option on interception missions is entirely satisfactory only when using a 45-degree approach angle. The 90-degree approach angle will probably be suitable for identification passes where closing velocities are not large.

(3) Data Link Output: This change was made to avoid excessive delay in system response to changes in tactics, especially when the interceptor nears the offset point. The data link output program has been modified to send out a complete set of command messages in the frame in which tactics change. In connection with this change, the 30-second time-to-go buffer at the offset point has been eliminated.

(4) Turning Rate Table: A new table of turning rates (degrees per frame for a standard 30-degree bank angle) was designed which gives rates as a function of interceptor speed and altitude, instead of using one constant rate for all types and all speeds.

(5) Missile Range and Velocity Table: This change in effect gives more positive identification of the interceptor type. The missile range and velocity table, used for making armament corrections, was previously indexed by squadron call letter (first letter only) which was unsatisfactory for crosstelling purposes. The table is now indexed by interceptor type.

(6) Table Space for Two New Interceptor Types: Space was left in the program to store standard speeds, climb characteristics, etc. for two more interceptor types, making a total of nine.

(7) Minor Deletions: The 5-degree quantization of attack headings has been eliminated because its use did not justify the program time required. A 7-1/2-second correction in the computed time-to-go calculation was eliminated since this time factor correction was allowed for in the new equations.

(8) Iteration Procedure: New interceptor headings are calculated from the last computed command heading instead of from magnetic north. In the case where an interceptor is assigned to a new target, the new heading is calculated from the current attack heading. As a result of these changes the no solution regions (i.e., regions where the interceptor's final turn exceeds 180 degrees) become more apparent. The zero-degree approach angle can be used only when the

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interceptor's lateral separation from the target path exceeds twice the turning radius of the interceptor.

b. Automatic Tracking

The automatic tracking function in the DCA program was modified to improve its ability to track turning aircraft. The change was based on a simulation study and the results of system testing in ESS. The preliminary conclusion is that the change provides a substantial improvement in tracking performance with no apparent deterioration of other functions. Further data is being collected for analysis of track heading and speed as well as intercept calculation.

c. Crosstell

The shakedown of the crosstell function was concluded on 23 April after three months of examination, modification, and testing. Model 0 of the DCA program, modified by Group 67 for use in ESS, was used. In the tests of the previous quarter, numerous discrepancies were discovered which rendered the function inoperative for shakedown purposes. After the modification and recoding of 14 subprograms, shakedown testing began with simulated data, using a specially designed test facility with effectively divided ESS into two adjacent sectors. These tests uncovered 39 program problems (predominantly in interceptor hand-over) and 12 system problems. Many of the program problems were corrected by Group 67, and by April the crosstell function could be tested with simulated data. Further testing with live inputs was not judged feasible.

The version of the crosstell function used in the ESS tests will not be used in SAGE. Many of the problems discovered in ESS testing are known to be covered by existing site investigations. Others, especially in weapons assignment and system operation are not. However, a detailed comparison between SAGE and ESS crosstell problems has not been considered worthwhile because of the differing structure of the ESS and production crosstell programs.

2. Modifications in Automatic Initiation

Modifications in the logic of the automatic initiation function have been incorporated in an experimental version of the DCA program. They are designed to provide added capability in the following ways:

(a) differentiate between three ranges of target speed

(b) cause increased rejection of clutter prior to the tentative tracking phase, thus saving track channels

(c) detect ambiguous situations which ordinarily would result in premature and probably incorrect initiation

(d) delay processing in these ambiguous situations for an additional frame

The modified function was tested with encouraging results. Present plans call for a comparative evaluation of the old and new logics using repeated short runs of recorded live data, first with the present program and then with the modified version. A constant active initiation area will be used which includes zones of single, double, and triple radar coverage. Comparisons will be made of program operating times, tentative track load, false tentatives, false establishments, initial pickup load, and delay to successful initiation.

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C. INVESTIGATION OF TECHNICAL PROBLEMS AT NYADS

Late in April representatives of Group 64, Group 67, and the 4620th ADW who are experienced in ESS testing went to the McGuire Direction Center in the New York Air Defense Sector to examine the operation of that sector. Their major goal was to make a detailed comparison between ESS and McGuire performance, and to define the tasks that might be undertaken to improve McGuire operation. In May a list of specific problems, suggested solutions, and priorities for each was compiled by Group 64 and the 4620th ADW. In general the problems were found to fall into these categories:

(1) program, equipment, and facilities
(2) operator job knowledge and proficiency
(3) effects of special test procedures used in final system tests
(4) lack of "operational" testing

On 29 May, another visit was made to examine the results of crosstell testing and to determine the capability of that function in the McGuire program. No major program deficiency was observed which might seriously hinder air defense capability. It was felt, however, that operator training and procedures were not as advanced as in other functions at McGuire. A further investigation of operational problems in the crosstell function was foreseen when crosstell is used in system tests in NYADS.

D. MEMORY TEST COMPUTER (MTC)

MTC was shut down permanently on 21 March after all data processing activities had been transferred to the recently acquired IBM 704. MTC, originally built to test the first ferrite core memory, had been modified and enlarged several times to increase its ability to reduce shakedown test data and to produce simulated-data-generation tapes. Since it was designed as a test vehicle, rather than as a high volume data processor, it did not lend itself to efficient maintenance techniques. The operation of the 704 is administered by Group 22.

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Unclassified

VACUUM TUBES

GROUP 65

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CLOUGH, T. F.

PALERMO, J. S.

Unclassified

V. VACUUM TUBES
GROUP 65

A. SUMMARY

The average life of the Stromberg-Carlson Charactrons in the AN/FSQ-7(XD-1) consoles continues to be about 5000 hours. The Machlett Laboratories' Scriptrons have improved to about 3000 hours.

Recent production Typotrons installed in consoles as replacements have been failing at an average rate of 800 hours. Hughes Aircraft has reverted for limited production of tubes to earlier (successful) production techniques. Sample tubes passed all acceptance specifications except write time and have been operating satisfactorily in the ESS consoles. Hughes certified that Machlett had qualified as second source for the Typotron. It is expected that their first production tubes will show the same early failure pattern of the recent Hughes productions.

Hughes constructed four 21-inch character-writing direct-view storage tubes in their program to develop a storage tube with controlled persistence for the SAGE situation display. Ten 5-inch electrostatic Tonotrons continued on the Group 65 life-test rack in an evaluation study of the storage surface used in the controlled persistence tubes.

Persistron panels which are persistent-emission solid-state display devices were developed for operation in a cathode-ray tube.

A program has been undertaken to study the dielectric breakdown problem that exists in the high-power klystron (X-626), used in the Millstone Hill experimental radar. An attempt is being made to eliminate the problem by coating the inside surface of the ceramic output window with a high resistance conductive coating.

B. DISPLAY

1. Charactron

Stromberg-Carlson's production realization rate declined steadily this year from 84% in January to 76% in May. Screen quality and grid emission became major production defects along with the lack of beam uniformity and high voltage leakage. Rejects for grid emission and high voltage leakage could be reworked so that a high percentage was acceptable on retest.

2. Scriptrons

The situation display consoles in AN/FSQ-7(XD-1) were filled with Scriptrons as sockets became available. Operational data on 34 Scriptrons show an expected life comparable to the Charactron. However, five of the six Scriptrons removed this quarter had an average life of 1185 hours due to a cathode problem associated with a new production line. This problem is expected to be corrected during the next quarter.

3. Typotron

a. Hughes Aircraft

Twenty-seven of the 44 Typotrons removed this quarter from XD-1 consoles were from

recent productions and all 27 failed because of poor storage and erasure characteristics with an average life of 800 hours.

Hughes made ten engineering samples employing the techniques used in earlier production tubes which have been giving an average life of 6000 hours. These samples passed all acceptance specifications except the write time. Four of the tubes were installed in XD-1 and have been operating satisfactorily. A production run of similar tubes was ordered on a thousand-hour pro rata warranty and with a waiver on the write-time specification.

b. Machlett Laboratories

Machlett made 25 sample preproduction Typotrons which were accepted by Hughes for evaluation. Hughes certified in May that Machlett had qualified as second source for the Typotron. It is expected that, because of close engineering liaison between Machlett and Hughes, the first production tubes will have the same early failure rate as the recent Hughes production.

C. RESEARCH

1. Controlled Persistence Tube

Hughes constructed four 21-inch all-glass Typotron tubes with a sandwich type storage target of magnesium fluoride and potassium chloride. One tube was shipped to the IBM Display Group for evaluation. Two tubes were not completely operable due to faulty wiring of the writing gun. However, valuable test information was obtained from the flood gun and storage target. The fourth tube was held at Hughes for their own evaluation. The designs of the writing gun, flood gun, and the multigap collimating lens are considered complete. The target used in these four experimental tubes closely approximates the optimum storage mesh dimensions as determined in a previous study program.

2. Tonotron Life Test

The type of storage surface used in the controlled persistence development is being life tested in ten 5-inch electrostatic Tonotrons on the Group 65 life-test rack. The tubes have been operating since the first of the year under conditions simulating SAGE operation without any failures or any degradation of the characteristics.

3. Solid-State Display Devices

The Persistron is a solid-state display and storage device consisting of an electroluminescent layer in series with a matrix of photoconductive elements with limited optical feedback to cause the output light to persist for several seconds after the input light has been removed. The panels are coated with cathodeluminescent phosphor and the input light is generated by striking this phosphor with a high velocity electron beam.

The basic objective of the program has been to study the feasibility of putting a Persistron panel on the inside face of a sealed-off cathode-ray tube. Persistron sandwich panels have been put on the inside face panels of 5-inch cathode-ray tubes but the solid-state panels as presently fabricated will not withstand a vacuum bakeout without degradation of the Persistron action. Although the action cannot be restored by further oxidation in vacuum, a life-test program of

several hundred hours indicates that the Persistron action reaches a stable equilibrium and there is no further deterioration.

Oxide cathodes in Persistron tubes have been activated without vacuum bakeout by attaching a titanium getter ion pump to each tube to continuously remove water vapor from the unbaked components and other gases from the electron bombarded photoconductor. These oxide cathodes have not been deteriorating on life of several hundred hours.

4. Thin Magnetic Films

The basic equipment used to prepare Permalloy films in Group 63 is a Consolidated Vacuum Corporation 18-inch bell-jar industrial-coating unit in which evaporation takes place at about 2×10^{-5} mm of pressure. Group 65 made thin films on their own high vacuum equipment and using special out-gassing techniques for the melt. Films could be produced in a vacuum better than 5×10^{-8} mm. However, they require several days of vacuum pumping and r-f melting of the large charge of iron and nickel. These films showed no improvement over films produced at a higher pressure.

5. Fiber Optics

American Optical Company has developed a technique of making plugs several inches in diameter of 0.002-inch diameter glass fiber. Group 65 developed a technique of sealing these plugs in the faceplates of cathode-ray tubes (Fig. 65-1). The light from the excited phosphor is transmitted through the plugs without the usual diffusion that takes place in the faceplate.

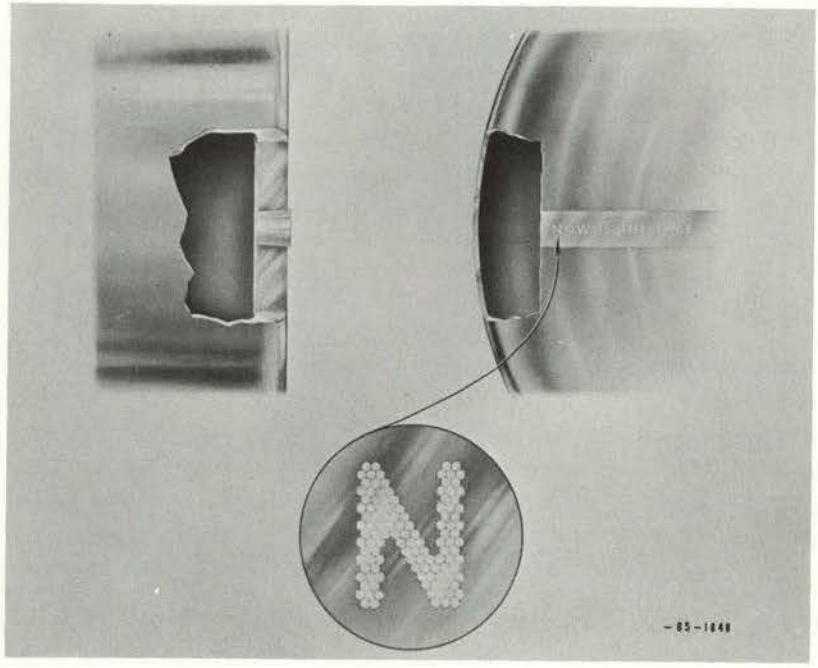

Fig. 65-1. Details of fiber optics faceplate.

A Charactron tube was constructed with a fiber optics plug in its faceplate and used for photographic purposes. Considerable improvement in sharpness and brightness of characters over that available from the regular Charactron was obtained.

6. High Power Klystron Tube – X-626

A serious dielectric breakdown problem exists in the high power UHF klystron tube developed for the Air Force by Eitel-McCullough and used in the Millstone Hill experimental radar transmitter. Power is taken from the klystron through a porcelain r-f window located adjacent to the collector. The collector is at ground potential while the cathode is operated at –100 kv. It has been found that when this tube is operated at 100 kv its life is limited by the dielectric breakdown of the r-f porcelain window. It is believed that the inside surface of the cylindrical window is being charged negative toward the cathode potential (–100 kv) by high velocity electrons. The charging produces a high potential gradient between the inside surface and metal rings which support the porcelain insulator. Dielectric breakdown and loss of vacuum occurs after a short period of operation at rated voltage. Group 65 proposed to eliminate or minimize the charging of the inside surface of the porcelain by the application of a high resistance conductive coating. The first type of conductive coating which will be applied and evaluated is stannic-oxide because of its excellent high-temperature adherence and controllable resistance quality. In order to evaluate the effectiveness of the conductive coatings, actual klystron operating conditions will be simulated. Group 31 is preparing a power supply and an isolation transformer capable of 100 kv operation. Group 65 will design and build the electron bombardment chamber and conduct the experiments.

SPECIAL STUDIES

GROUP 66

ISRAEL, D. R., *Leader*

BENTON, D. I.

CALLAHAN, T. R.

KIRSHNER, H. J.

NORRIS, R. C.

ROBERTS, A. J.

SIFNAS, MARTHA E.

STYLOS, P.

THOMPSON, S. L.

GROUP 66

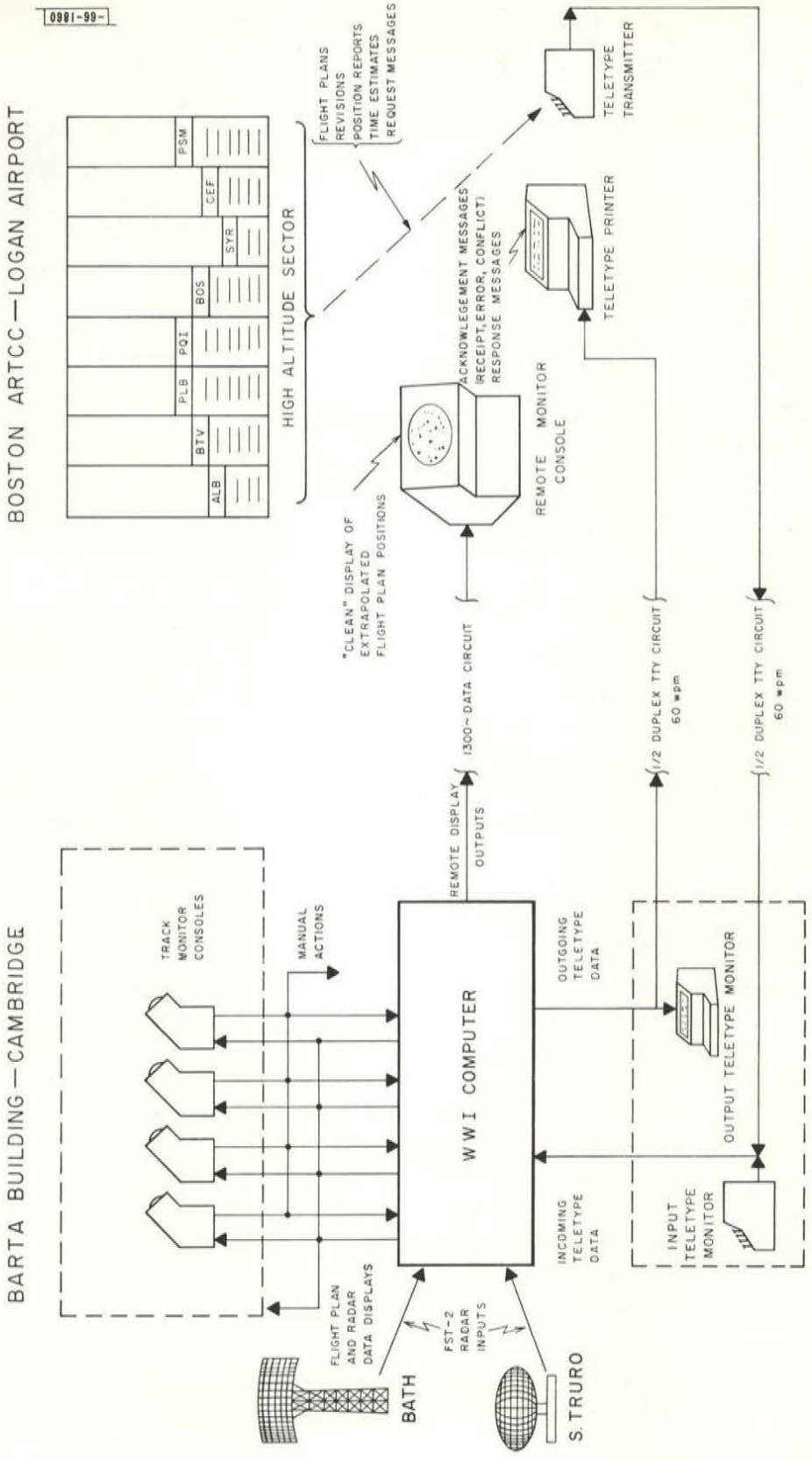

Fig. 66-1. Information flow for CHARM system.

VI. SPECIAL STUDIES
GROUP 66

A. SUMMARY

CHARM (CAA high altitude remote monitor) is an experimental system which has been begun by Lincoln Laboratory to demonstrate and evaluate the ability of a SAGE-like air surveillance system to assist the CAA in air traffic control. Cooperation between both systems has been suggested by the imminent completion of the first sectors of the SAGE system and the growing requirements of the nation's air traffic control system. In particular, accurate, up-to-date air movements information is essential to each.

The planning for CHARM began in January 1958. During February and March six tests were conducted using the Cape Cod System to verify the methods of flight plan correlation. First drafts of detailed operational and mathematical specifications were completed by the end of March. In April and May the preparation of a computer program for the Whirlwind I computer was begun, and negotiations progressed for the procurement and installation of the necessary equipment at the Barta Building (location of Whirlwind I) and at the Boston Air Route Traffic Control Center (ARTC).

B. OPERATIONAL DESCRIPTION

The essential components of the CHARM system are shown schematically in Fig. 66-1. Flight plans, position reports, and other air movements information from the High Altitude Sector of the Boston ARTC will be transmitted directly to the Whirlwind I computer by on-line, manually-operated teletypewriters, and will there be processed and displayed to track monitors. The monitors will use displays of incoming radar data from ESS radar sites to correlate and correct flight plan positions. The computer will then encode and transmit the resulting flight plan positions to the ARTC where they will be displayed on a remote monitor console for reference and orientation.

1. ARTC: Source of Flight Plan Data

The source of flight plan data for CHARM, including flight plans, position reports and/or estimates, and flight plan revisions, will be the High Altitude Sector of the Boston ARTC. This sector, normally manned by a single controller and one or more assistants, has a responsibility for all aircraft above 24,000 feet over the entire Boston ARTC area, marked by the heavy line in Fig. 66-2. The control procedure and techniques presently employed are essentially the same as those used for low altitude traffic, with each flight plan broken down into flight progress strips and posted on flight progress boards. The inputs to the High Altitude Sector are primarily teletype and interphone messages from SAC bases, CAA communication stations, and adjacent ARTC's, as well as direct voice radio communication with the inflight aircraft.

2. CHARM Inputs

a. Teletype

The data collected and available at the ARTC will be transmitted via teletype to Whirlwind I.

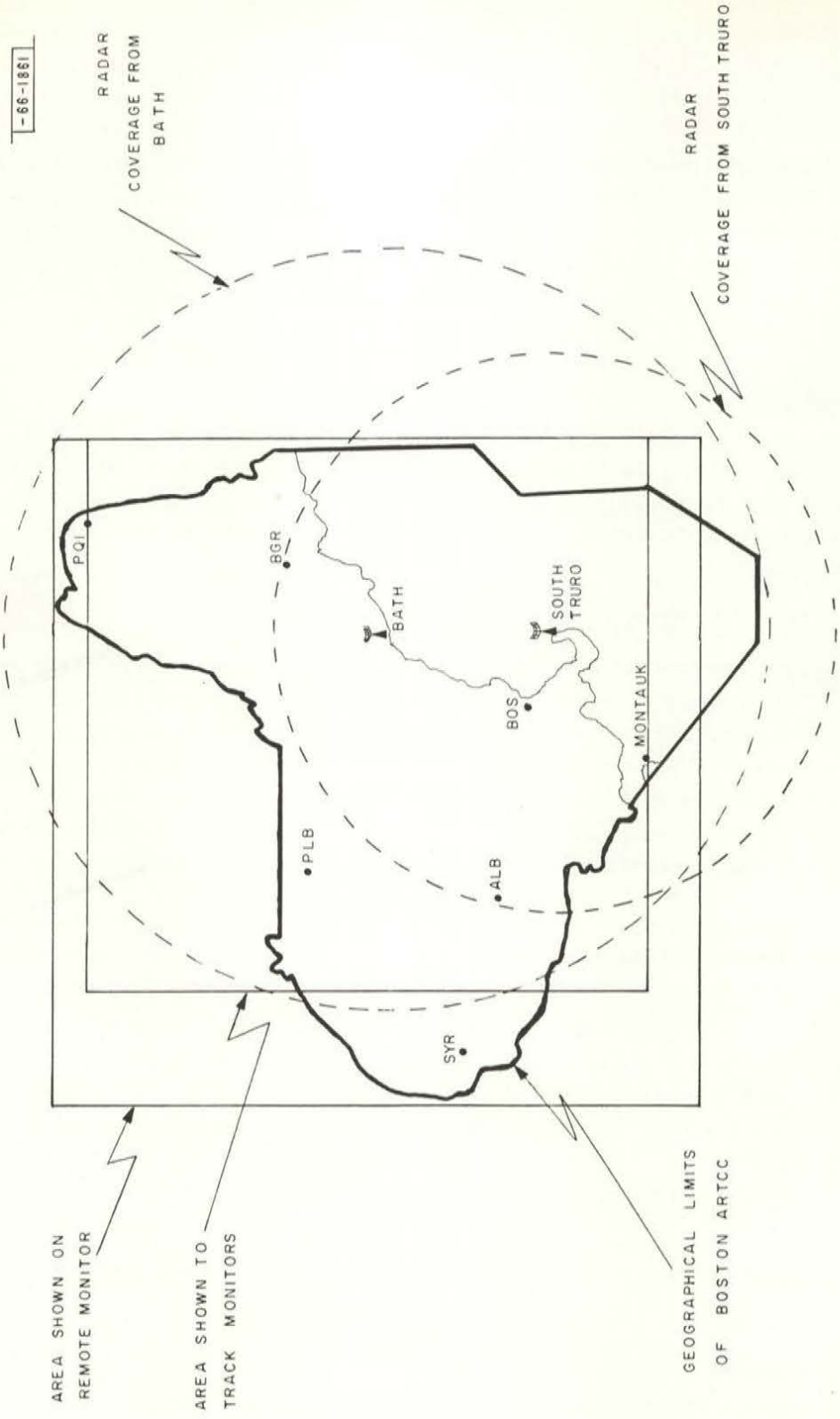

Fig. 66-2. CHARM geography.

The transmitting machine will be a keyboard-operated 28 KSR which produces page copy at the transmitting point and is connected directly to the computer by a one-half duplex, 60 wpm circuit. Messages generated by the computer will, in turn, be directly available at the ARTC via teletype. Thus, personnel at the ARTC will have direct, two-way communication with the computer. Teletype input messages will be of these types:

(1) Flight Plans

(2) Flight Plan Revisions (including cancellations)

(3) Position Reports, including actual or estimated times. Position reports will normally be accepted only if they refer to a point on a previously filed flight plan. Supplementary reporting points, however, may be used to give a position over a point not initially filed; such reports will also be made when an aircraft leaves a warning area or is asked to report over a supplementary fix on an approach to an airport.

(4) Code Word Routes. These are similar to flight plans, except that they define a route of flight that a number of aircraft may later follow. Subsequent flight plans, then, may indicate the use of a previously filed code word route rather than specifying the complete route again. Code word routes may also be used for designating commonly used departure paths from airports or airbases.

Each kind of teletype input message will be distinguished by identifying characters, message content, and message sequence. Considerable flexibility is permitted, particularly in the specification of a flight plan route where fixes, positions related to fixes, latitude-longitude, airways, code word routes, or combinations thereof may be used. In general, message content and sequence is in accordance with normal CAA practice and will use standard abbreviations, location identifiers, etc. Special procedures will help prevent, detect, and eliminate teletype operator errors, and the computer program will inspect incoming messages for errors in format and message content.

b. Storage and Updating of Flight Plans

CHARM will accept and process air movements data for flights within or immediately adjacent to the Boston ARTC area. This function will require the permanent storage within the computer of geographical information relating to reporting points, navigational aids, airways, and warning areas. With this information, each incoming flight plan, regardless of the form in which the route was filed, will be decoded into a series of fixes, or geographical locations, for storage within the computer. For experimental convenience, the initial capacity of CHARM has been set at 24 flight plans, each of not more than 15 fixes.

Filed flight plans will remain inactivated until a teletype message is received containing a reported time for the first fix in the stored route. The computer will then calculate estimated times of arrival for each subsequent fix along the route, using the filed flight plan speed and the stored information relating to the separations between fixes. The calculated times of arrival over the fixes will then be continuously updated and corrected in accordance with position reports, speed changes, and flight plan revisions as contained in subsequent teletype input messages. From these fix times, the current or present position of the flight plan can be determined at any time by interpolation, placing it between two fixes in accordance with the distance between them and the elapsed time.

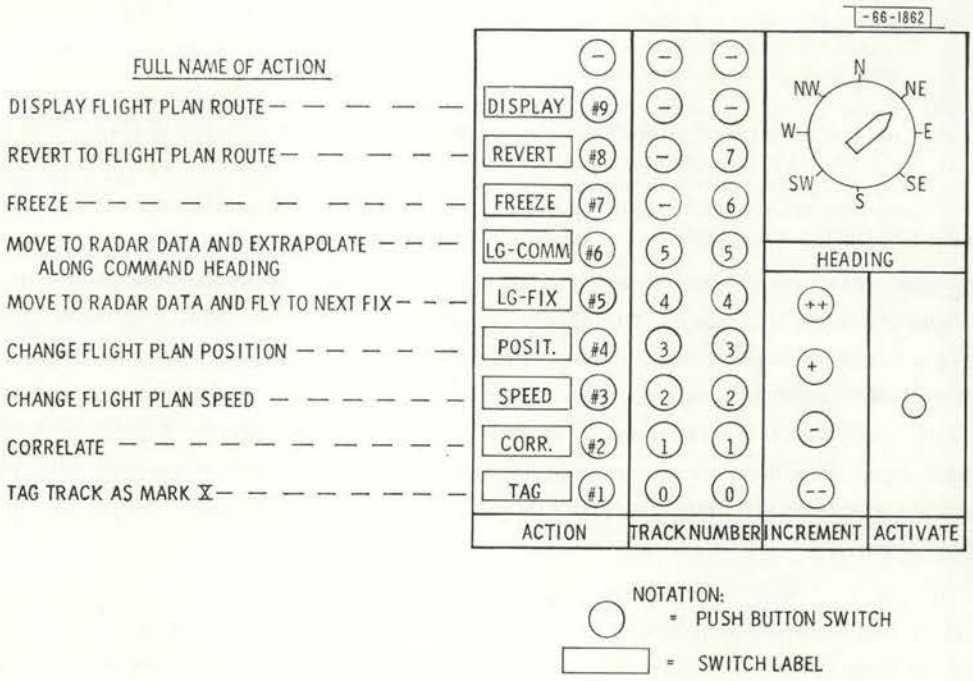

Fig. 66-3. Layout of track monitor switch panels.

c. Radar and Mark X

Radar data inputs to CHARM will be from the Lincoln Laboratory – operated AN/FPS-31 at Bath, Maine, and AN/FPS-20 at S. Truro, Mass., both equipped with Mark X beacon interrogators. The coverage to be expected from these radars on SAC-type aircraft operating at about 30,000 feet is shown in Fig. 66-2. Consistent coverage is anticipated since almost all aircraft operating at the high altitudes now respond to Mark X interrogations. Both search and Mark X data will normally be processed by AN/FST-2 coordinate data transmitters at Bath and S. Truro and transmitted over telephone circuits to Whirlwind I where it will be converted to a common coordinate system and processed for display. Several past scans of incoming data will be retained in computer storage for use in a radar history display.

3. Track Monitor Function

Incoming radar data, stored radar data history, and present flight plan positions, as calculated from flight plan messages and position reports, will be displayed on four track monitor consoles located in the Barta Building in an operations room adjacent to the computer. The principal duties of the track monitors will be to correlate the radar data with the present flight plan positions and to supply such corrections to the flight plan positions as are necessary. In those cases where flight plans do not specify routes (radius flights or flights in warning areas), the radar data will be the primary means of determining actual aircraft positions. The track monitors will also be shown key geographical points and selected flight plan routes. The area shown in the track monitor display is outlined by the smaller square in Fig. 66-2. It is designed to take maximum advantage of radar coverage yet provide the largest possible display scale.

In performing his correlation, correction, and tracking functions, the track monitor will have a light gun and a number of switches to communicate his intentions and data to the computer. These inputs will be used to supplement the stored flight plan data and supply corrections where needed. When an aircraft is proceeding directly from one point to another the track monitor should normally need to make only small speed or position corrections.

It should be noted that CHARM, in its initial configuration, does not include a track-while-scan function in which radar data is processed to form radar tracks. Rather, CHARM will extrapolate flight plan tracks derived from flight plans and make the radar data available for manual corrections.

4. ARTC Remote Display

After the computer has processed the flight plans and the track monitors have acted on them, a display will be generated and transmitted to the ARTC. The display will be a plan position presentation of the current and expected flight plan positions, as corrected or modified by track monitor actions, over an area roughly coincident with the area controlled by the Boston ARTC (See Fig. 66-2). The display will supplement the flight progress strip postings used by the air traffic controllers at the High Altitude Sector.

5. Communication to the ARTC

The facilities and formats used in the transmission of data to the remote monitor console

will be similar to those used for SAGE crosstell messages; 1300 bit-per-second telephone data circuits will carry the data. The messages will up-date the entire display (24 flight plan positions) once each minute.

Two output teletype messages that may prove to be useful to the traffic controller at the High Altitude Sector will also be provided. The first is a response message containing a statement of the present position of the flight plan with respect to its last fix and its expected time of arrival over the next fix. This message will be generated by the computer only upon teletype request. The second message is intended to indicate whenever a potential conflict exists over some fix. A conflict is here defined as a time separation of less than ten minutes and altitude separation of less than 2000 feet between flight plans. It should be noted that conflicts will be detected only over specific geographical fixes; in this sense, this feature is only a demonstration of a potential capability of a full conflict determination. A conflict message, specifying the fix and conflicting flight plans, will be generated by the computer whenever an input message contains information which indicates that such a conflict will exist.

C. DESIGN FEATURES

1. Error Correction and Detection

An error correction facility is provided to the ARTC teletype operator, allowing him to "back group" with the character X. For example, if the operator intends to type the group BOS, but instead types BPS, the error may be corrected by the operator as in the following sequence:

CEF BED BPS X BOS

One of the objectives of initial CHARM tests will be to attempt to determine the types of errors most frequently made by teletype operators and whether the error correction facility provided is sufficient.

It is assumed that some errors will elude detection or correction by teletype operators. For this and other reasons, all input teletype messages will be examined by the computer to determine whether they contain errors which may arise in typing, procedure, or transmission. The teletype operator will receive an indication as to whether the message he has transmitted is accepted or whether it contains an error. If an error is detected by the program, an automatic teletype output message will tell the operator the point in the message at which the error has been detected. Routes will be checked for coherence; for example, if a number of airways are filed to define a route, successive airways must intersect. Format will be checked to determine that storage capacity is not exceeded for certain items.

2. Coordinate System and Geographical Data Storage

The computer will store the location of 225 geographical points and fixes and 95 airways within and adjacent to the Boston ARTC area. These will include the positions of reporting points and navigational aids, such as VOR, LF-MF range stations, radio beacons, and outer markers. Some flight plans will specify routes in terms of latitude and longitude or in terms of warning areas. The coordinate positions for latitude-longitude pairs and the identification and center of warning areas will also be stored by the computer.

3. Track Monitor Actions and Displays

The function of the track monitors is to monitor computer displays which show the extrapolated or "present" flight plan positions together with the radar data from the S. Truro and Bath sites, and to make such correlations and corrections of flight plan positions as seem necessary. The correlation or identification of corresponding radar data returns and flight plan positions will depend upon the judgement of the track monitor: he will consider the proximity of the data, the direction of flight, the past and future flight plan route, and in some cases, the type of radar return – search or Mark X. These actions are intended to improve the flight plan data; if no actions are taken, the flight plan remains unchanged.

The facilities available for track monitor actions will be:

a light gun, for use on radar data displays
an ACTION switch panel
two TRACK NUMBER switch panels
an INCREMENT switch panel
a rotary HEADING switch panel
an ACTIVATE button

Four identical track monitor positions will handle a total of 24 flight plans. The assignment of flight plans to monitors will be by SOP, probably on an area basis. There will be five displays available: flight plan track display; flight plan route; present radar data; radar data history; and selected geographical points (see Fig. 66-4 and 66-5). All will be updated and presented every 6 seconds.

4. Conflict Search

The check for conflicts will be made whenever a fix time for a flight plan is calculated, recalculated, or corrected. To assist in this check, the computer will store for each fix a list of the flight plans incorporating that fix: whenever a fix time is calculated or changed, the computer can immediately determine what other flight plans are using that fix and can then check their times and altitudes over the fix. The detection of a conflict will result in the generation of an output teletype message.

5. Remote Monitor Display

The remote monitor console is a prototype designed by Group 63. A typical display, updated each minute, contains the following plan position information in a 550-mile square (see Fig. 66-6): (a) geographical points; (b) present track positions with a minimum of symbology and no extraneous information; and (c) expected positions, as an aid in predicting short-range conflicts. The display tube will provide a bright, flicker-free picture. It is a Tonotypotron developed by Hughes Aircraft Co. with the following features:

(a) a 21-inch face, with a selection of 64 characters in the Charactron-like matrix;
(b) a controllable persistence which can be set to values of up to several minutes;
(c) a brightness sufficient for daylight viewing.

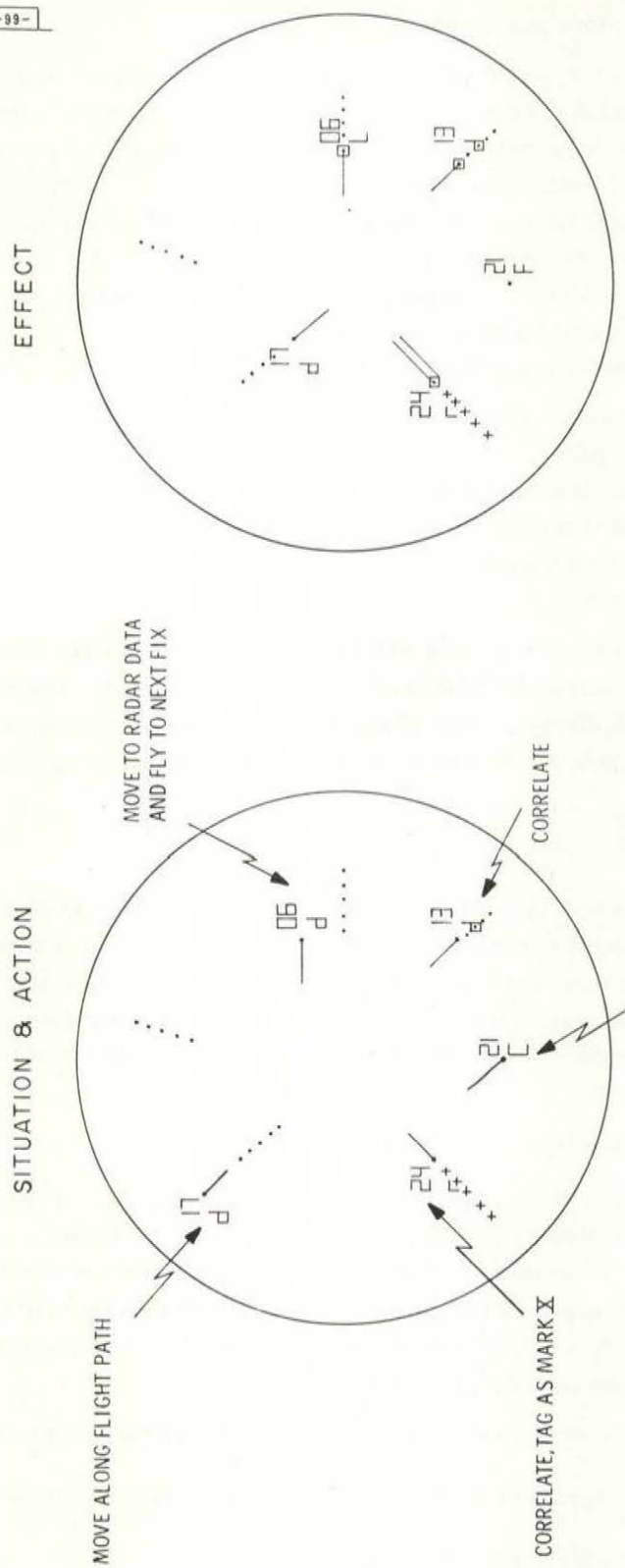

Fig. 66-4. Examples of track monitor actions.

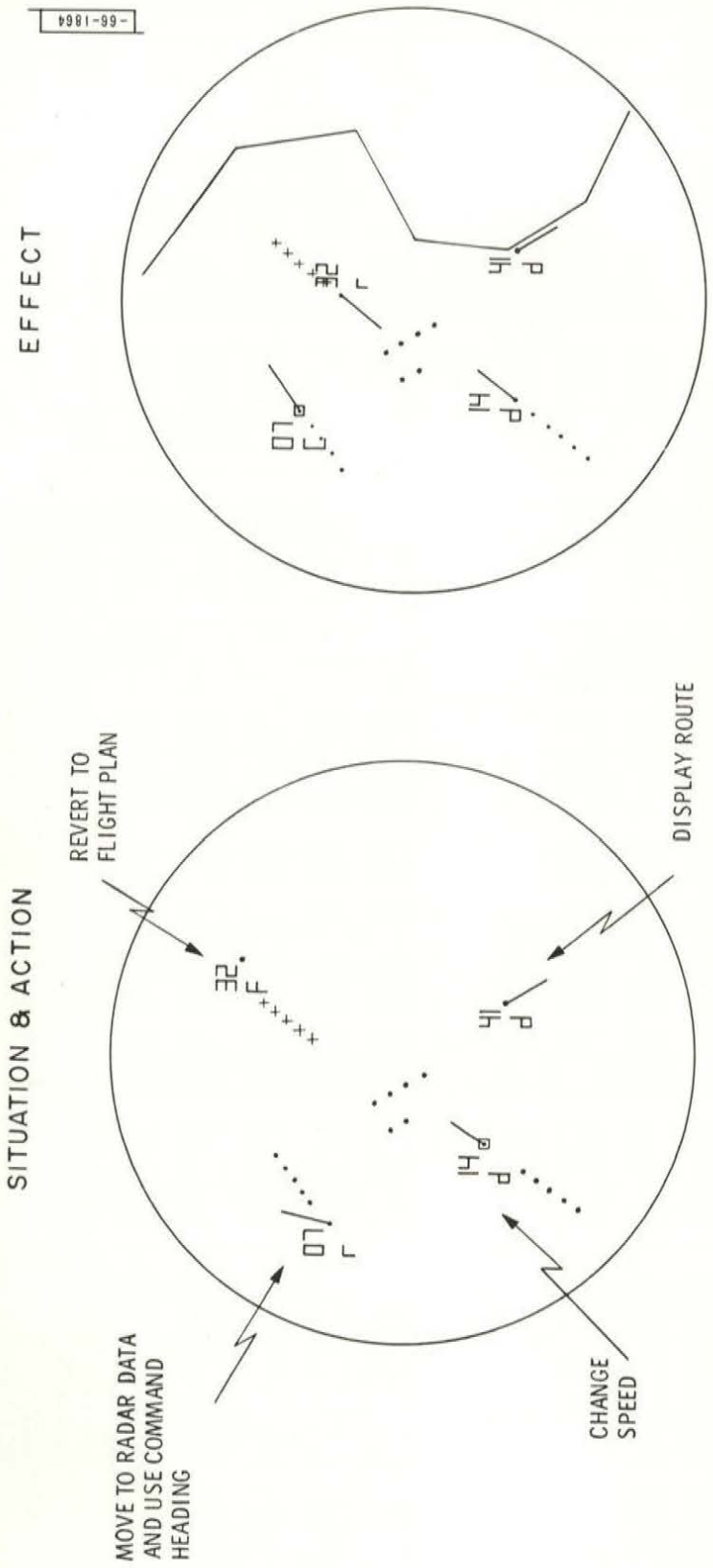

Fig. 66-5. Further examples of track monitor actions.

-66-1865

NOTATION

□PQI FIX LOCATION AND DESIGNATOR

● FLIGHT PLAN POSITION – RADAR CORRELATION

• FLIGHT PLAN POSITION – NO RADAR CORRELATION

POINTS INDICATE, IN SUCCESSION:

PRESENT POSITION
POSITION IN 2.5 MINUTES
POSITION IN 5.0 MINUTES
POSITION IN 7.5 MINUTES
POSITION IN 10.0 MINUTES

FIRST AND SECOND LINES OF SYMBOLOGY ARE AIRCRAFT DESIGNATION

THIRD LINE OF SYMBOLOGY IS ALTITUDE(3 DIGITS) AND FLIGHT SIZE (1 DIGIT)

ALTITUDE:
VFR, OR
100'S OF FEET

FLIGHT SIZE:
NO DISPLAY IF SINGLE AIRCRAFT,
DECIMAL DIGIT FOR 2-9 AIRCRAFT,
+ FOR > 9 AIRCRAFT

EXAMPLES

NAVY #32451 AT 33,000 FEET, NO RADAR CORRELATION, FLIGHT PLAN INDICATES TURN.

SAC NIMROD 85, VFR ALTITUDE, RADAR CORRELATION, 3 AIRCRAFT

LIMITS OF USABLE DISPLAY: 420-MILE SQUARE CENTERED AT 44°N 72°W.

Fig. 66-6. Typical remote monitor display.

Normally, the persistence control will be set for a sharp cut-off at one minute to coincide with the receipt of new information from the computer.

6. Computer and Computer Program

CHARM will require a completely new computer program of 7500 instructions or more. The preparation of this program is now underway, and its completion is expected in late summer. In accordance with the exploratory nature of CHARM, an attempt has been made to design a system which is both flexible and expandable. Thus, priority has been given to the design of an expandable computer program structure, to which additional programs can be later added.

D. FLIGHT TEST VERIFICATION

During February and March of 1958, six test sessions were conducted using the Cape Cod System. Qualitative verification was made of some of the methods of flight plan correlation designed for CHARM and situations peculiar to the high altitude operation were investigated. The following are some general conclusions drawn from the tests:

(1) Despite deviations of aircraft from flight plans, radar data from high altitude aircraft can be correlated with flight plans in areas of relatively low traffic. Rapid display of new flight plans and rapid updating with position reports is a definite aid in establishing correlation.

(2) Knowledge of route configuration is helpful in the correlation of radar data with flight plan.

(3) The ability to revise flight plans rapidly and frequently is essential for high altitude operation.

(4) The system must be able to handle lengthy flight plans containing a variety of fixes (navaids, airways, latitude-longitude, warning areas, radius flights, distance direction from navaids, omniradial intersections, refueling areas, jet departure routes) in any combination.

(5) Flight plan speed is not reliable, but position reports can be used to correct extrapolated positions. Reduction in horizontal speed on climbout can cause difficulty in extrapolation.

(6) Manual conversion from the language of the flight plan to georef fixes is a time-consuming, error-prone process; in CHARM the conversion will be performed automatically.

(7) Automatic tracking lightens the monitor load, especially in the case of warning area and radius flights.

ADVANCE SAGE PROGRAM DEVELOPMENT

GROUP 67

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BUDD, ELEANOR J.
BURROWS, J. H.
BYRNE, W. J.
CHANDLER, A. R.
CHOMSKY, CAROL S.
CLAPP, ELIZABETH S.
CRADDOCK, MARCIA J.
CURTIS, R. G.
DAVIS, R. C.
EARL, D. B.
FERGUSON, MARY E.
FRACHTMAN, H. E.
GOCHMAN, H.
HAGER, L. S.
JONES, K. L. (LOA)
LEVENSON, JUDITH A.
LUNDBERG, E. D.
MARKO, J. T.
MEAD, W. H.
MILBERT, A. J.
ORNSTEIN, S. M.
RIAL, J. F.
RISING, H. K.
SEDGEWICK, NORMA L.
SMITH, SONIA F. G.
THOMAS, D. J.
THOMAS, L. M.
VANDERBURGH, A., Jr.
YNTEMA, MARY K.

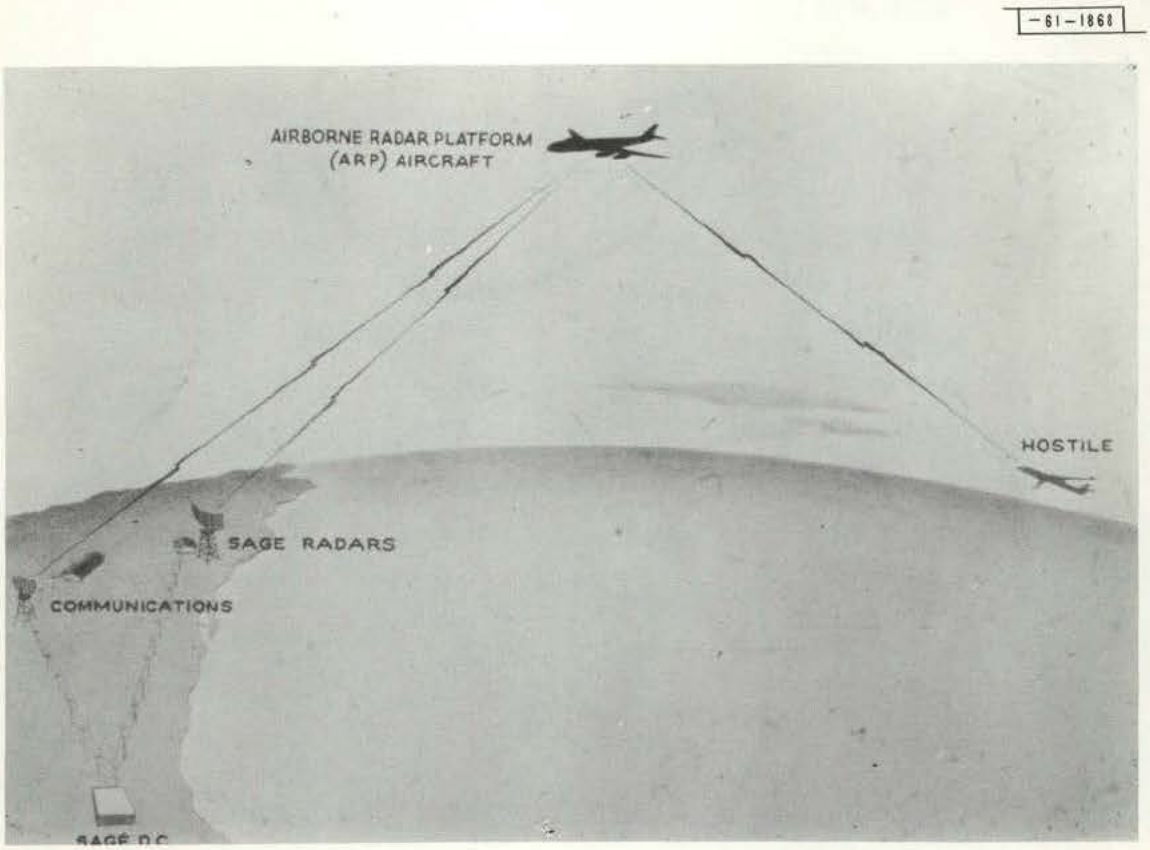

Fig. 67-1. ALRI operational concept. (Reproduced from "Joint Presentation – IM-99B/SAGE Employment Conference, April 28 – May 2, 1958, Seattle, Washington, D 5-2952")

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VII. ADVANCE SAGE PROGRAM DEVELOPMENT
GROUP 67

A. SUMMARY

Operational specifications for the airborne long range radar input (ALRI) system were begun as were modifications to the direction center active (DCA) program in the Experimental SAGE Sector (ESS) necessary to demonstrate the ALRI system. Preparations for Mark X (SIF) integration in the air defense system were described in four aspects: integration in ESS, integration in SAGE, evaluation test requirements in SAGE, and revision of the operational and mathematical specifications. SAGE direction center air surveillance capability was studied: the effect of different parameters in the automatic tracking program was evaluated; the initiation of simulated high speed tracks was attempted; the dual tracking feature was refined and found more effective than the present SAGE tracking program for maneuvering tracks; and height finder error data were correlated with target range. An investigation of passive tracking under ECM conditions was started with two simulation programs.

B. INTERIM OPERATIONAL SPECIFICATIONS FOR ALRI

The writing of operational specifications for the ALRI system was begun. ALRI will extend SAGE radar coverage, air surveillance, identification, and weapons direction into the seaward approaches of the U.S. Unlike the present airborne early warning system, ALRI will send quantized, digitalized radar data to SAGE direction centers via receiving stations and phone-line communications to supplement air surveillance data from existing land-based radar sites. With ALRI, SAGE weapons control will be extended to roughly 300 miles out from the coast at high and low altitudes. The essential operation of the initial experimental ALRI system is described briefly in the following paragraphs. (See also Fig. 67-1.)

1. General

The radar-carrying aircraft will operate within radar and radio line of sight of the shore communication facilities, and the direction center will keep track of the aircraft's position by standard SAGE air surveillance techniques, supplemented by auto-navigator data from the aircraft. The radar data, both search and Mark X, will be quantized and processed for target detection and beam-splitting in the aircraft and transmitted via digital data link to a ground receiving station. The ground station will process the data for phone-line transmission to the LRI frame of the direction center, where the DCA program will use it for initiation, tracking, identification, and weapons assignment in a way similar to that used for search and gap filler data from ground sites. Height requests will be made and acknowledged by voice radio-telephone much as in current SAGE manual mode height finding.

2. Aircraft Equipment

In the initial ALRI system, an RC121D or WV2 aircraft will carry a modified AN/FPS-70 search radar, a modified AN/APS-45 height radar, a digital data processor, and a digital data transmitter. It will cruise at about 17,000 feet for maximum line-of-sight radio and radar ranges.

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3. Shore Stations and Communications

Two types of receiving equipment will be required on the shore to receive information from the aircraft: a data link receiver for the radar data, and a voice channel receiver for operational control and, in the initial ALRI system, for height finding. The data link receiver output will be placed on phone lines for transmission to the LRI frames of one or more direction centers.

4. Data Processing Equipment*

Two kinds of data processing equipment will be built for the ESS ALRI System. In Phase I, a digital target detector will be installed at Lincoln Laboratory and will process quantized video data, radar triggers, north markers, and azimuth change pulses and convert the data into a form suitable for phone-line entry into the AN/FSQ-7 (XD-1) LRI drum field. Later a data processor will be built for airborne installation.

5. Directional Reference and Navigation

The initial ALRI system will be provided with an airborne directional reference system to be used in orienting the height finder and as an accurate true north reference for the search and Mark X data. The system, called ERDR (Earth's Rotation Directional Reference) is a newly developed gyrocompass made by Dynatrol.

6. Direction Center

The ESS ALRI system will require no new equipment in the direction center, other than telephone line terminal equipment for voice and digital circuits and labels for presently unused console push-buttons. No new operating positions or console changes are necessary.

7. DCA Program Changes

A number of changes in the DCA program will be necessary to process ALRI data. Among these changes are radar inputs processing, radar masking, tracking logic, initiation, and height finding. Group 67 began designing these changes during the quarter. Some features of the modified program are:

(a) Radar data from the moving aircraft will be transformed into the stationary SAGE coordinate system.

(b) The ALRI data, which in the near future will be processed by FST-2 type equipment, will be filtered by the program to eliminate multiple azimuths appearing at the same range.

(c) Separate search area dimensions and smoothing constants will be used for ALRI data.

(d) There will be switch features to enable tracks to be smoothed on ALRI data alone, on non-ALRI data alone, or on a mixture. This will provide a means for measuring and portraying registration errors in the experimental system.

(e) A new tracking sub-status will be introduced (LRI status, analogous to Mark X status) to provide a measure of isolation among the processes of tracking with Mark X data, tracking with search data, and tracking with ALRI data.

*See Section II, B of this report.

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(f) There will be switch features to enable the orientation angle of the airborne radar used in the data conversion process to be varied dynamically.

C. MARK X SIF

Four aspects of the incorporation of the Mark X Selective Identification Feature (SIF) in the air defense system have been described: integration in ESS, integration in SAGE, test requirements for evaluation in SAGE, and revision of the operational and mathematical specifications. SIF is to become operational in USAF aircraft in the Continental U.S., Alaska, and the Northeast Territories on 1 January 1959.

1. Integration in ESS

In order that ESS retain its present capability, it was proposed that the sector be equipped to use all or part of the SIF system. The plan proposed by Group 67 calls for the installation of SIF in three phases:

Phase I (prior to 1 January 1959): A passive decoder, an interrogator, and associated equipment will be installed in the AN/FST-2's at the Bath, S. Truro, and Montauk radar sites. These will enable ESS, which can now operate with basic Mark X, to operate with SIF-equipped interceptors. No program changes will be required.

Phase II (April 1959 – January 1960): The Montauk AN/FST-2 will be equipped with an SIF code detector. When the DCA program is modified for SIF tracking, ESS will have the capability to operate with SIF-equipped aircraft through this radar data.

Phase III (after January 1960): The Bath, S. Truro, and TT-2 radar sites should be equipped with SIF detectors, and ESS will be fully capable of operating with the feature.

2. Integration in SAGE

A number of problems are being investigated with respect to SAGE integration of SIF. Chiefly, these come under three headings: (1) the need to devise interim capability between January 1959, when SIF becomes operational, and the time when production equipment and computer program capability will become available; (2) the provision of facilities and procedures for the joint use of one beacon system by the Air Defense Command (ADC), the Civil Aeronautics Administration (CAA), and Anti-Aircraft Artillery (AAA); and (3) higher power requirements for SIF operation with the BOMARC missile to obtain greater coverage.

3. A SAGE Test Plan

The testing with SIF which will be required in order to specify equipment configurations, parameter settings, and detailed operational procedures in SAGE will be described in a test plan undertaken this quarter. In particular, an evaluation of the AN/FST-2 detector and decoder will be necessary, and the interference levels specified in the ADC employment plan for SIF will have to be determined with respect to three operational options for SAGE use of the feature. A draft of the test plan is expected during the next quarter.

4. Revision of Operational and Mathematical Specifications

Operational changes in the DCA program, especially in the tracking function, are described in "Operational Specifications for IFF Mark X SIF Tracking in the Revised 1959 System," 6M-4459-1, 3 April 1958. This memorandum, a revision of an earlier proposal* written by Group 61, describes changes in radar data inputs, initiation, track monitoring, and other functions related to SAGE tracking needed to implement the ADC employment plan for SIF.†

D. SAGE DIRECTION CENTER AIR SURVEILLANCE

1. Investigation of SAGE Tracking Function

In an effort to determine the most effective parameters and logic for the SAGE automatic tracking function, a radar data generation program (TDG) and a tracking and analysis program (TNA) were written and the tracking function was subjected to a variety of situations. The situations included: a 20-, 40-, and 60-degree weave, an 80-degree turn with and without 100-knot deceleration, an untracked data trail crossing a tracked data trail at a variety of angles, and an untracked data trail moving parallel to a tracked data trail. The investigation was concerned mainly with four parameters:

(a) the smoothing constants of the aircraft coordinates in the search area
(b) the sizes of both large and small search areas
(c) the "good distribution check" on data in the large search area
(d) the "box check" on data in the large search area.

The general conclusion drawn from the test results is that no one set of parameters is best for all tracking situations. In particular, it was observed that the larger smoothing constants in the large search area yielded poorer straight line tracking results. Enlarging the small search area, to prevent the data from wandering into the large search area, improved the feature, however. Larger large search areas were demonstrably better for isolated track turning situations, but worse in crossing track and parallel track situations. In these tests, a 1.5, 5.5 mi. search area combination seemed best. During straight line tracking the deviation of the track from its data is a function of the errors in the data, and hence the small search area size may well be determined by the radar data errors.

2. Initiation of High Speed Tracks

A study was begun to determine the ability of the SAGE system to perform manual track initiation on high speed aircraft. Although the results of initial tests are incomplete and in some cases contradictory, a tentative conclusion was reached that present search areas are too small to initiate tracks travelling at over 1000 knots. A small search area with a 2-mile radius on the first 15 frames of track life appears to be the minimum requirement. Other changes in the program were observed to have a beneficial effect; for example, a change in a subroutine which allows correlation with newly initiated tracks to take place two subframes earlier. The study will continue, using the DCA program.

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* "Proposal for SAGE Tracking in IFF Mark X SIF Era," 6M-4459, 10 July 1957.

† "Plan for Employment of Mark X Selective Identification Feature," ADC Document 57-3285, April 1957.

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3. Dual Tracking

Dual tracking,* a modification of the automatic tracking function in the DCA program, was further analyzed and tested to find the best parameters and to evaluate the function's effectiveness. As a result of the study, several changes to the specifications were made, the effect of which is to improve tracking resolution in areas of dense radar returns. The most significant was the elimination of the large search area of the dual track and the increase from 2.5 to 3 miles in the radius of the small search area. Other changes were made (1) in the correlation function for tracks in overlap coverage; (2) in the positional smoothing constant for the small search area of the principal track (increased from 3/16 to 1/4);(3) in search vector logic; and (4) in the logic for trouble detection and split detection.

The tests of dual tracking were made on AN/FSQ-7 (XD-1) using the SARD (simulated aircraft radar data) tape and the DCA program. The capability of dual tracking was compared with that of the SAGE automatic tracking function in turning, splitting, parallel, crossing, and straight-line tracks. A detailed report of the results of these tests is to be published next quarter. Observed results indicated that dual tracking is a definite improvement over the older program.

4. Height Finding Error Analysis

Height finder error data collected by Group 22 in Evaluation Tests Nos. 6, 8, and 9 (November 1957), were analyzed to determine what relationship might exist between height error and target range. The error was calculated as the difference between the altitude as reported from altimeter readings and the AN/FPS-6 height finders at S. Truro and Bath.

Preliminary results of the analysis include the following observations:

(a) there is a linear (not quadratic) relation between height error and range; in one sample of 111 observations on 18 aircraft, the correlation between error and range was 0.7689, for a mean error of +1070 feet.

(b) residual error dispersion is a function of range.

(c) height returns have a probable error of 500-600 feet in addition to a bias varying with range.

(d) probable registration errors between two height finders could be reduced to less than 800 feet if the range-dependent bias were eliminated.

E. COUNTER-COUNTERMEASURES DATA PROCESSING STUDY

In connection with SAGE air surveillance capability proposed for the post-1960 system, a study is underway to investigate SAGE tracking problems under ECM conditions. Emphasis is being placed on passive tracking, especially in overdense situations when several jamming aircraft make their location by triangulation difficult. This investigation follows from and complements the Crossover study of Division 2. Group 67 will attempt to combine the results of their passive tracking study with those of Crossover to produce a description of an active-passive tracking capability for the SAGE air surveillance function.

During the quarter, two computer programs were begun to assist in the above study: (1) a simulation program to generate strobe returns typical of overdense jamming, and (2) a display program to present the data at one or more consoles in ESS.

*Quarterly Progress Report, Lincoln Laboratory, M.I.T., Division 6 (15 December 1957) Section VII, B, 1.

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SYSTEM OFFICE

GROUP 68

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HOLDEN, W. E.

IPPOLITO, V. O.

LINEHAN, L. H.

MAY, J. P.

OGDEN, W., Jr.

PARKINS, T. R.

SHOREY, R. R.

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VIII. SYSTEM OFFICE
GROUP 68

A. SUMMARY

The Initial SAGE Problem Committee processed 49 changes to the design of the SAGE System during the quarter. Subcommittees were established to process changes for the Experimental SAGE Sector (ESS) and to study the manual inputs function in SAGE.

Eleven additional changes were processed by the System Office for retrofitting to Models 1, 2, and 3 of the direction center active (DCA) program as a result of an evaluation made by Group 64 of the system problems in the New York Air Defense Sector. Other necessary changes will be specified during the next quarter.

The "Design and Implementation Status of the 1960 SAGE System," published early in May, describes the new features that have been designed for the 1960 computer program and states the prospects of meeting the desired operational dates for each feature.

B. THE INITIAL SAGE PROBLEM COMMITTEE

The Initial SAGE Problem Committee had evaluated and processed 49 changes to the design of the SAGE System and were actively considering 35 more at the end of the quarter. A total of 42 new design changes was proposed during the quarter, bringing the total number of System Office Evaluation Requests up to 310. Beginning with meeting no. 10, held on 13 March 1958, ISPC minutes were published as 6M-notes.

Two subcommittees were established: (1) to study changes that affect ESS only or are to be installed in ESS for evaluation before installation in SAGE, and (2) to study the manual inputs function to determine changes that should be made to improve its efficiency in SAGE.

C. MODEL 1 OF THE DCA PROGRAM

The System Office requested that eleven additional changes be installed before the operational date of each sector to Models 1, 2, and 3 of the DCA program. The changes resulted from an evaluation of system problems in the New York Air Defense Sector (NYADS) made by Group 64 and the results of a meeting held on 13 May 1958 with representatives from Lincoln, WE-ADES, BTL, IBM, SDC, the 4620th ADW, and NYADS. The changes included a revision of SAGE radar data equations, additional display categories for several consoles, an improved slant/range correction, and a change in the display expansions at all IND consoles. Other changes considered necessary by Group 64 were being processed by the System Office.

Eight changes in the intercept direction function, previously recommended for inclusion in Models 1, 2, and 3 of the DCA program at all SAGE sites where these models will be installed, were retrofitted at NYADS on 1 May 1958. The changes were recommended by the System Office after successful trial tests in ESS by Group 64 and SDC.

D. MODEL 3 OF THE DCA PROGRAM

A proposal to provide emergency capability (Mode II) in Model 3 was received from SDC after an urgent request from ADC that the feature be available for early operation. Seven changes,

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Feature	Program Model	Program Date	DC Equip.	External Equip.	Communications	Testing	Training
BOMARC							
Montgomery	3B	1 May 59	Jun 59	Jun 59	Jun 59	plans incomplete	plans incomplete
New York	5	1 Jul 59	Sep 59	Sep 59	Sep 59		
Manned Interceptors							
Interim	3	1 Feb 59	Feb 59	Feb 59	none required	plans incomplete	plans incomplete
Improved	*	*	Jan 60	Jan 60			
Antiaircraft							
Interim	2	15 Sep 58	Sep 58	Sep 58	Sep 58	plans adequate	plans incomplete
Improved	no schedules						
Mode II Emergency Capability	3	1 Feb 59	Feb 59	not affected	not scheduled	plans incomplete	plans incomplete
SIF Tracking of Manned Interceptors	no schedule		not affected	Jan 59	not affected	plans incomplete	plans incomplete
Time-Division Data Link	no schedules						
Weapons Assignment	no schedules						
SAGE System Training Program							
Interim	*	Apr 60†	plans adequate	not affected	not affected	not affected	not affected
Long-Range	*	Apr 60†					

* Information not available.

† Long range SSTP scheduled for installation at Kansas City at same time installation of interim SSTP to be begun at other sectors.

Fig. 68-1. Implementation status of the 1960 SAGE System.

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considered by the System Office to be critically needed in Model 3, were not included in SDC's proposal. Among these are the changes to provide for overlap telling from manual to SAGE direction centers, and those to increase the capacity and flexibility of SAGE operation with Missile Master and manual AADCP's. The System Office accepted the proposal with the urgent request that SDC include the needed changes in Model 3.

E. THE 1960 SAGE SYSTEM

"Design and Implementation Status of the 1960 SAGE System," 6M-5663, was published on 5 May 1958. The report, presented by Lincoln Laboratory to ADC at Colorado Springs on 7 May 1958, describes the new features that have been designed into the 1960 computer program and the prospects of meeting the desired operational dates for each feature. The new capabilities are described briefly below and their status is summarized in Fig. 68-1.

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1. Increased Track Capacity

The program track capacity will be increased to 300 tracks from 100 tracks of the program for the initial SAGE System. The system processing capacity (the number of tracks that a SAGE direction center will be able to accept, correlate, identify, display, etc.) will vary from about 280 tracks for a light combat load to about 170 tracks for a heavy combat load, depending upon the density of the tracks, the percentage of interceptions in final phase, the number of display and switch actions per frame, and other variables. This increase in track capacity will be built up as SDC recodes the DCA program while incorporating new features in it, and reorganizes it to operate in the 65,536-core memory.

2. BOMARC Control

SAGE direction centers will be capable of controlling the firing and guiding of BOMARC IM-99A missiles. Program capability for BOMARC control is expected to be available for the demonstration firings scheduled for the Montgomery Sector in the summer of 1959.

3. Manned Interceptors

The 1960 SAGE System will take advantage of the increased speed and maneuverability, advanced fire-control systems, and high performance of the F-86L, F-89H, F-89J, F-101B, F-102A, F-104A, and F-106A interceptors by providing for, among other things, the automatic selection by the computer of cruise altitudes and speeds ("profile selection") and combat altitudes and speeds ("tactic selection"). An interim program capability is expected to be available in Model 3 of the DCA program. No schedules exist upon which to base an estimated program capability date for the whole improvement which is desired by early 1960.

4. AN/FSG-1 Missile Master

SAGE/Missile Master operations will be coordinated so that the computer program will, in the interim phase, automatically select and pass track reference data to Missile-Master equipped AADCP's and, in the improved phase, will automatically assign tracks to batteries. The program

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capability for the interim phase of SAGE/Missile Master operation is scheduled to be provided in Model 2 of the DCA program in time for the testing scheduled for October 1958 in the Washington Sector. No prediction can be made as to when the improved phase will be available.

5. Mode II Emergency Capability

A Mode II emergency capability will be provided so that the air defense responsibilities of a disabled direction center may be taken over by adjacent direction centers with a minimum of deterioration in system performance. It is expected that program capability for Mode II operation will be provided in Model 3 of the DCA program.

6. SIF Tracking

SIF (selective identification feature) tracking of BOMARC missiles will be provided for in initial use of the IM-99A. A proposed specification for SIF tracking of manned interceptors has been written, but when the program capability will be provided is not known. The operational date for Mark X (SIF) in the Continental U. S., Alaska, and Northeast areas has been directed by the Joint Chiefs of Staff as 1 January 1959. SAGE will be compatible with the beacon system during the transition from Mark X (basic) to Mark X (SIF), but SAGE tracking using SIF codes will be done at some later date.

7. Time-Division Data Link

The output sections needed at the direction center and the equipment external to the direction center will be available by mid-1960, the USAF target date for implementing TDDL for manned interceptors. However the computer program capability has not yet been scheduled.

8. Weapons Assignment

Improved methods of weapons assignment will be provided to increase the rates at which both targets and weapons can be committed. No schedules exist for providing the program capability for this feature.

9. Dual-Machine SSTP

Dual-machine SSTP (SAGE System Training Program) will be provided for in the 1960 SAGE System in two steps: interim and long range. Kansas City will have a long range capability in April 1960 and the installation of an interim dual-machine facility will begin in other sectors at the same time.

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ADMINISTRATION AND SERVICES

GROUP 60

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GROVER, C.S.

HAZEL, F.P.

HEDISON, H.H.

HILL, A.P.

HODGDON, H.W.

KATES, W.A.

MILLER, R.C.

MORLEY, H.B.

SMITH, A.R.

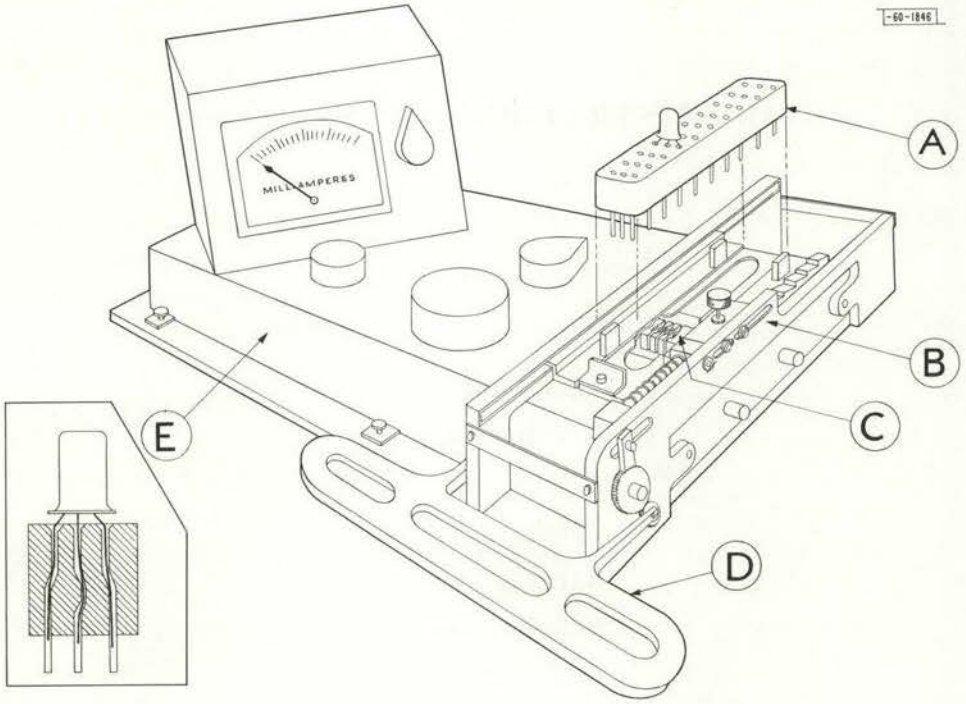

Fig.60-1. Multi-unit transistor tester. Up to ten transistors are inserted in the block holder (A) which is then placed in the carriage assembly (B). Each set of three protruding contacts under the block makes electrical connection with three spring contacts (C) as the operator steps the block forward with the hand treadle (D). The electronic assembly (E) can be interchanged with others for different tests. The insert shows how the transistor leads make friction contact inside stainless steel tubes molded in the block.

IX. ADMINISTRATION AND SERVICES
GROUP 60

A. SUMMARY

The activity of Group 60 is mainly of a supporting nature. The General Engineering Section, which furnishes design, fabrication and assembly services to the division provided Group 63 with a multi-unit transistor tester which reduces handling and shortens test time. The joint tape-and card-processing facility handled 5.9 million cards for the users of AN/FSQ-7 (XD-1) and the IBM 704. Whirlwind I was maintained with an average reliability of 98.8%.

B. GENERAL ENGINEERING

A multi-unit transistor tester was designed and fabricated for quantity testing by Group 63. The most important feature of the design is that transistors are held in blocks of cast epoxy resin during all 15 electrical tests and in the subsequent storage. The principal advantage of this feature is that the handling of individual transistors is reduced and testing time is proportionately shortened. Other advantages are mentioned below.

The transistor leads are inserted into stainless steel tubes (.040" I. D.) set in a block of cast epoxy resin approximately 6" × 1" × 1-3/8". The leads make friction contact at bends in the tubes (see Fig.60-1). There are 10 transistor positions (three holes each) in a block and the transistors remain in the block through all phases of testing and in the subsequent storage period.

Testing is done in a combination assembly which contains the required electronics and a carriage that holds the block as the operator advances each set of protruding tubes into berylium copper fingers where electrical contact is made. Only one type of electrical test is made for a given block or set of blocks, thus the operator has only two actions to make for each transistor: (1) advance the block by means of a hand treadle; (2) record the readings. The other electrical tests are performed on additional testers; it is also possible to exchange the electronics on a common carriage.

Some other features of the design are:

(1) constant lead length is maintained for each transistor and for each electrical test

(2) the block is reversible for tests where it is desired to reverse the emitter and collector

(3) the transistor leads are easily pushed into or withdrawn from the tubes in a single motion

(4) the carriage is stepped by a ratchet and pawl with an overriding feature for return

C. CARD- AND TAPE-PROCESSING FACILITY

The joint facility to process computer program materials for users of AN/FSQ-7 (XD-1) and the IBM 704 reports 5.9 million cards processed and 4510 hours of line printer usage. The users can be grouped roughly into the following categories: support of SAGE and ESS, research, administrative support, and miscellaneous.

D. WHIRLWIND I

The maintenance of WW I and its associated input-output equipment continued throughout the quarter without important incident. The performance of the computer, including input-output equipment, was as follows:

Total Computer Hours	1541.4
Per Cent Good Time	98.8
Mean Free Time (Hours)	28.2
Average Lost Time per Interrupting Incident (Hours)	.25

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